Machine Learning with Scikit-Learn

Andreas Mueller (NYU Center for Data Science, scikit-learn)

Material: http://bit.ly/sssklearn2015

Me


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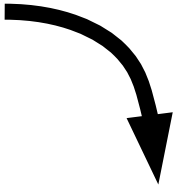
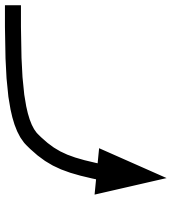



Amazon
Machine
Learning




NYU
Center for
Data Science

Classification
Regression
Clustering
Semi-Supervised Learning
Feature Selection
Feature Extraction
Manifold Learning
Dimensionality Reduction
Kernel Approximation
Hyperparameter Optimization
Evaluation Metrics
Out-of-core learning
……


agramfort
Alexandre Gramfort


AlexanderFabisch
Alexander Fabisch


alextp
Alexandre Passos


amueller
Andreas Mueller


arjoly
Arnaud Joly


bdholt1
Brian Holt


bthirion
bthirion


chrisfilo
Chris Filo Gorgole...


cournape
David Cournapeau


duchesnay
Duchesnay


dwf
David Warde-Farley


fabianp
Fabian Pedregosa


GaelVaroquaux
Gael Varoquaux


glouppe
Gilles Louppe


jakevdp
Jake Vanderplas


jaquesgrobler
Jaques Grobler


jnothman


kastnerkyle
Kyle Kastner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Wei LI


larsmans
Lars


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Mathieu Blondel


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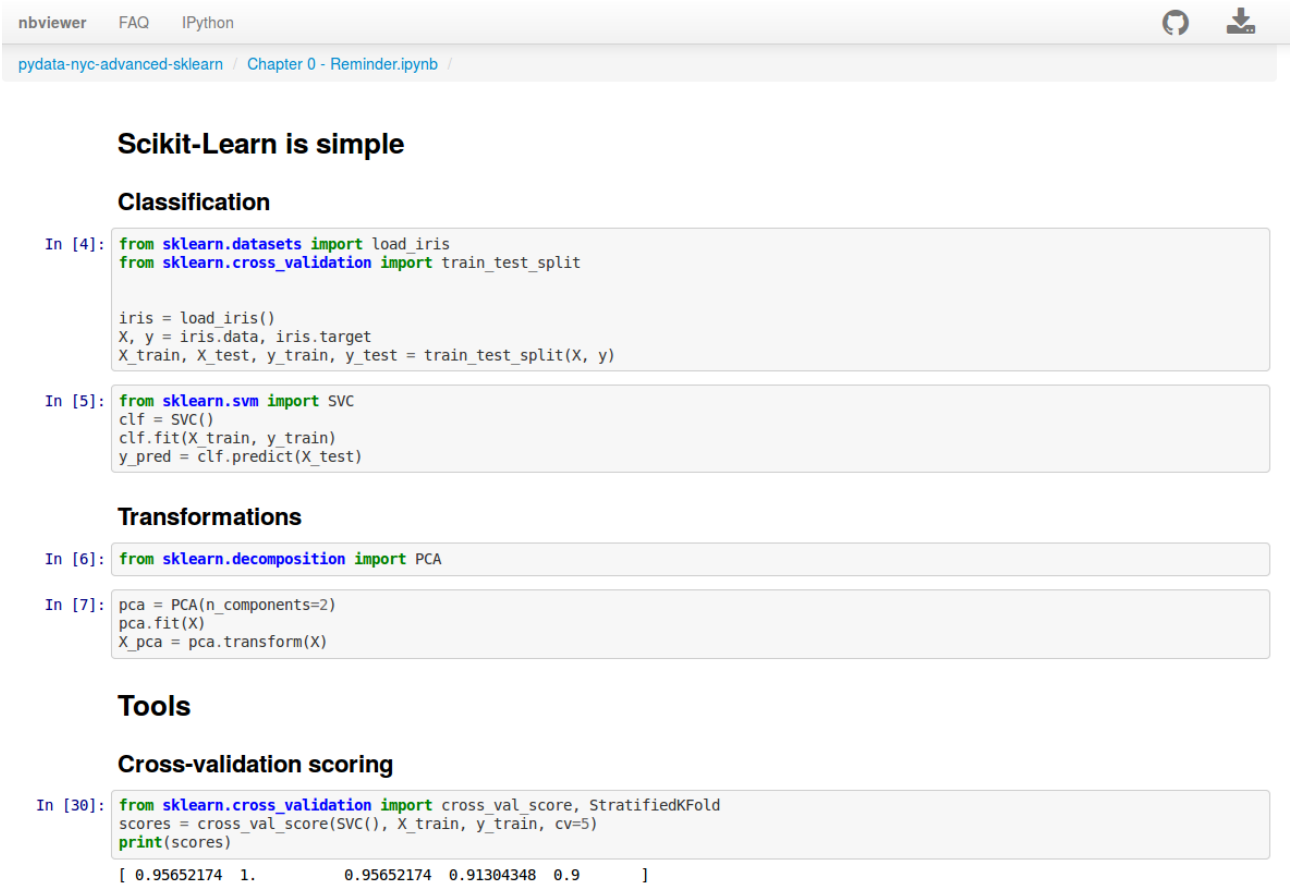
Vincent Michel


yarikoptic
Yaroslav Halchenko

Get the notebooks!



http://bit.ly/sssklearn2015

Home Installation Documentation Examples

Google™ Custom Search Search

Documentation of scikit-learn 0.17

Quick Start

A very short introduction into machine learning problems and how to solve them using scikit-learn. Introduced basic concepts and conventions.

User Guide

The main documentation. This contains an in-depth description of all algorithms and how to apply them.

Other Versions

- scikit-learn 0.18 (development)
- scikit-learn 0.17 (stable)
- scikit-learn 0.16
- scikit-learn 0.15

Tutorials

Useful tutorials for developing a feel for some of scikit-learn's applications in the machine learning field.

API

The exact API of all functions and classes, as given by the docstrings. The API documents expected types and allowed features for all functions, and all parameters available for the algorithms.

Additional Resources

Talks given, slide-sets and other information relevant to scikit-learn.

Contributing

Information on how to contribute. This also contains useful information for advanced users, for example how to build their own estimators.

Flow Chart

A graphical overview of basic areas of machine learning, and guidance which kind of algorithms to use in a given situation.

FAQ

Frequently asked questions about the project and contributing.

http://scikit-learn.org/

Hi Andy,

I just received an email from the first tutorial speaker, presenting right before you, saying he's ill and won't be able to make it.

I know you have already committed yourself to two presentations, but is there anyway you could increase your tutorial time slot, maybe just offer time to try out what you've taught? Otherwise I have to do some kind of modern dance interpretation of Python in data :-)
-Leah

Hi Andreas,

I am very interested in your Machine Learning background. I work for X Recruiting who have been engaged by Z, a worldwide leading supplier of Y. We are expanding the core engineering team and we are looking for really passionate engineers who want to create their own story and help millions of people.

Can we find a time for a call to chat for a few minutes about this?

Thanks

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Can we find a ti for a few minutes about t

Thanks

Doing Machine Learning With Scikit-Learn

Representing Data

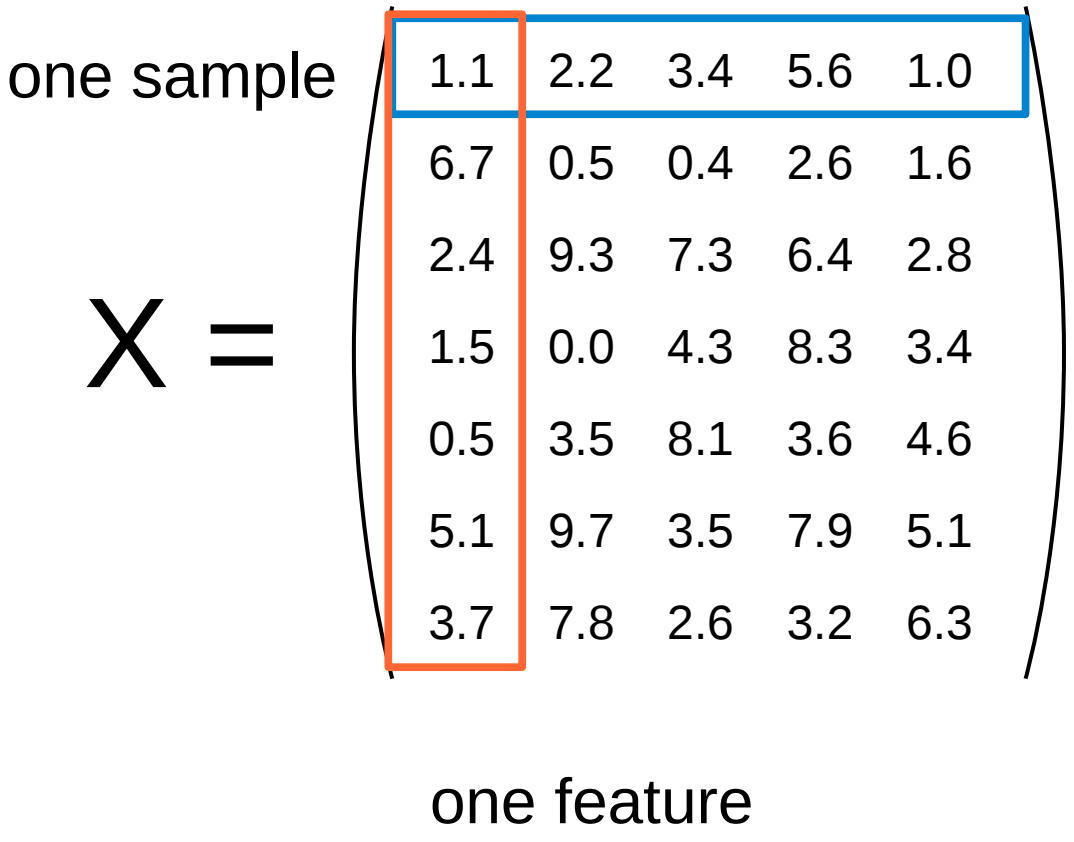
$$X = \begin{pmatrix} 1.1 & 2.2 & 3.4 & 5.6 & 1.0 \\ 6.7 & 0.5 & 0.4 & 2.6 & 1.6 \\ 2.4 & 9.3 & 7.3 & 6.4 & 2.8 \\ 1.5 & 0.0 & 4.3 & 8.3 & 3.4 \\ 0.5 & 3.5 & 8.1 & 3.6 & 4.6 \\ 5.1 & 9.7 & 3.5 & 7.9 & 5.1 \\ 3.7 & 7.8 & 2.6 & 3.2 & 6.3 \end{pmatrix}$$

Representing Data

one sample

$$X = \begin{pmatrix} 1.1 & 2.2 & 3.4 & 5.6 & 1.0 \\ 6.7 & 0.5 & 0.4 & 2.6 & 1.6 \\ 2.4 & 9.3 & 7.3 & 6.4 & 2.8 \\ 1.5 & 0.0 & 4.3 & 8.3 & 3.4 \\ 0.5 & 3.5 & 8.1 & 3.6 & 4.6 \\ 5.1 & 9.7 & 3.5 & 7.9 & 5.1 \\ 3.7 & 7.8 & 2.6 & 3.2 & 6.3 \end{pmatrix}$$

Representing Data



Representing Data

one sample

$$X = \begin{pmatrix} 1.1 & 2.2 & 3.4 & 5.6 & 1.0 \\ 6.7 & 0.5 & 0.4 & 2.6 & 1.6 \\ 2.4 & 9.3 & 7.3 & 6.4 & 2.8 \\ 1.5 & 0.0 & 4.3 & 8.3 & 3.4 \\ 0.5 & 3.5 & 8.1 & 3.6 & 4.6 \\ 5.1 & 9.7 & 3.5 & 7.9 & 5.1 \\ 3.7 & 7.8 & 2.6 & 3.2 & 6.3 \end{pmatrix}$$

one feature

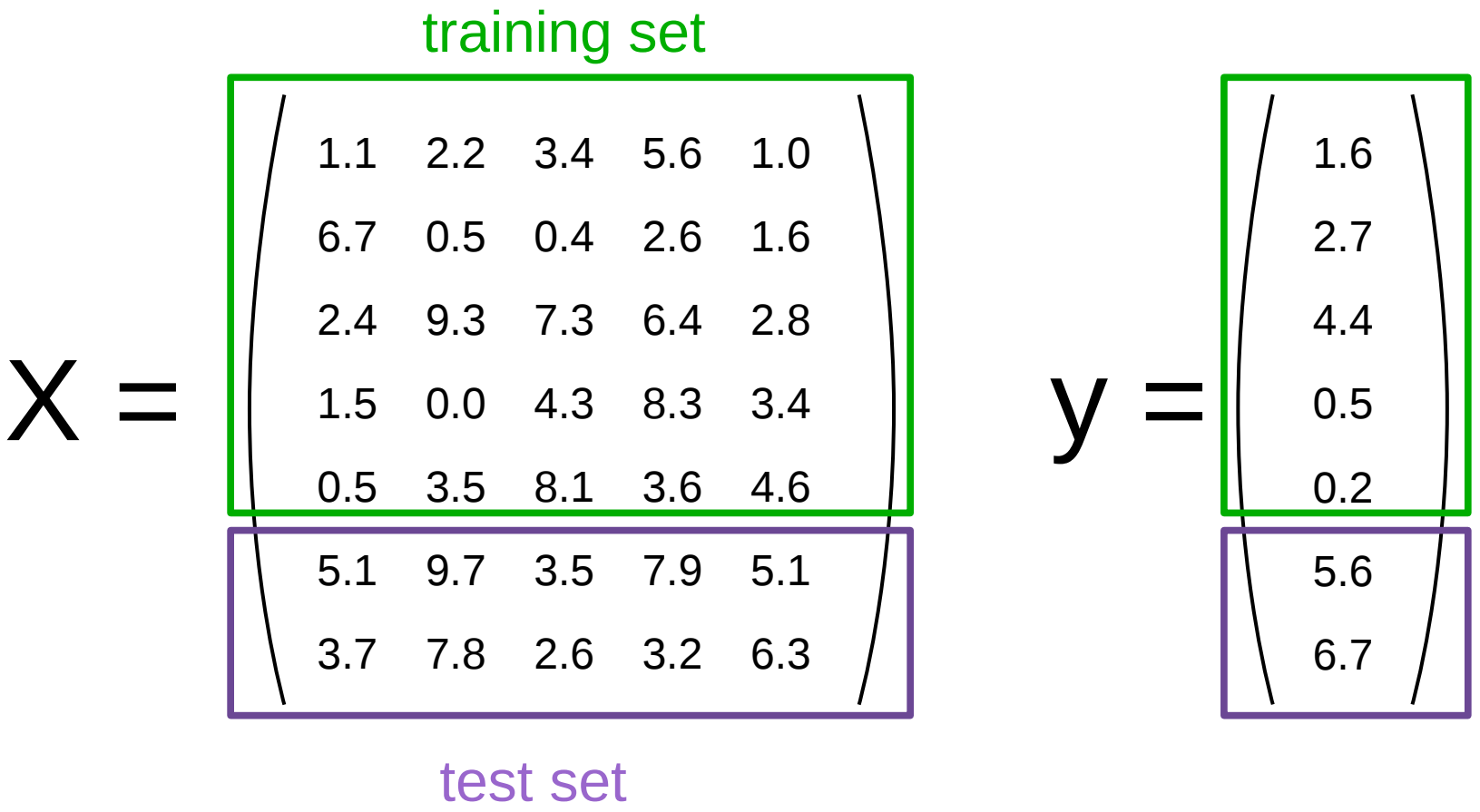
$$y = \begin{pmatrix} 1.6 \\ 2.7 \\ 4.4 \\ 0.5 \\ 0.2 \\ 5.6 \\ 6.7 \end{pmatrix}$$

outputs / labels

Training and Testing Data

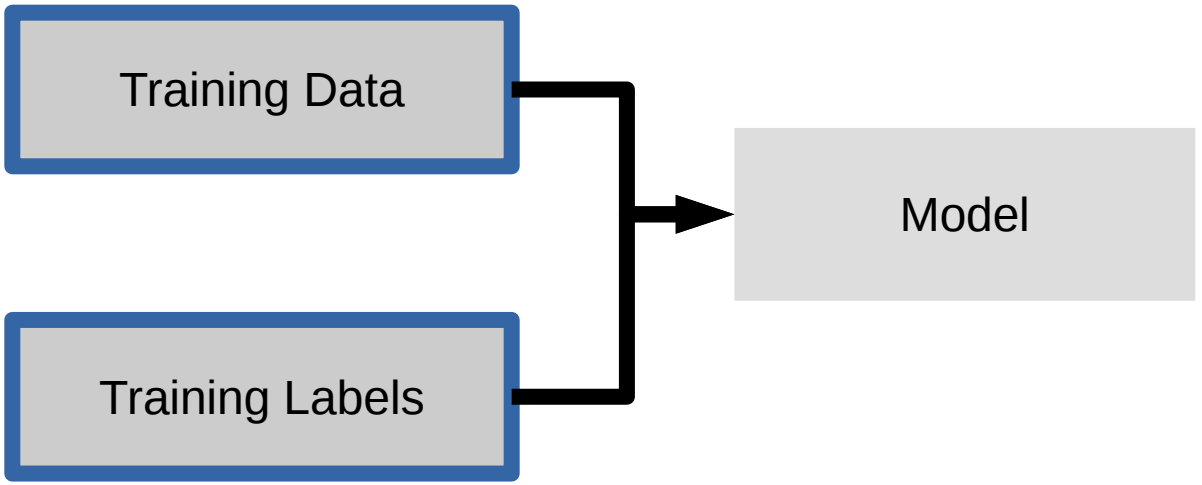
$$X = \begin{pmatrix} 1.1 & 2.2 & 3.4 & 5.6 & 1.0 \\ 6.7 & 0.5 & 0.4 & 2.6 & 1.6 \\ 2.4 & 9.3 & 7.3 & 6.4 & 2.8 \\ 1.5 & 0.0 & 4.3 & 8.3 & 3.4 \\ 0.5 & 3.5 & 8.1 & 3.6 & 4.6 \\ 5.1 & 9.7 & 3.5 & 7.9 & 5.1 \\ 3.7 & 7.8 & 2.6 & 3.2 & 6.3 \end{pmatrix} \quad y = \begin{pmatrix} 1.6 \\ 2.7 \\ 4.4 \\ 0.5 \\ 0.2 \\ 5.6 \\ 6.7 \end{pmatrix}$$

Training and Testing Data

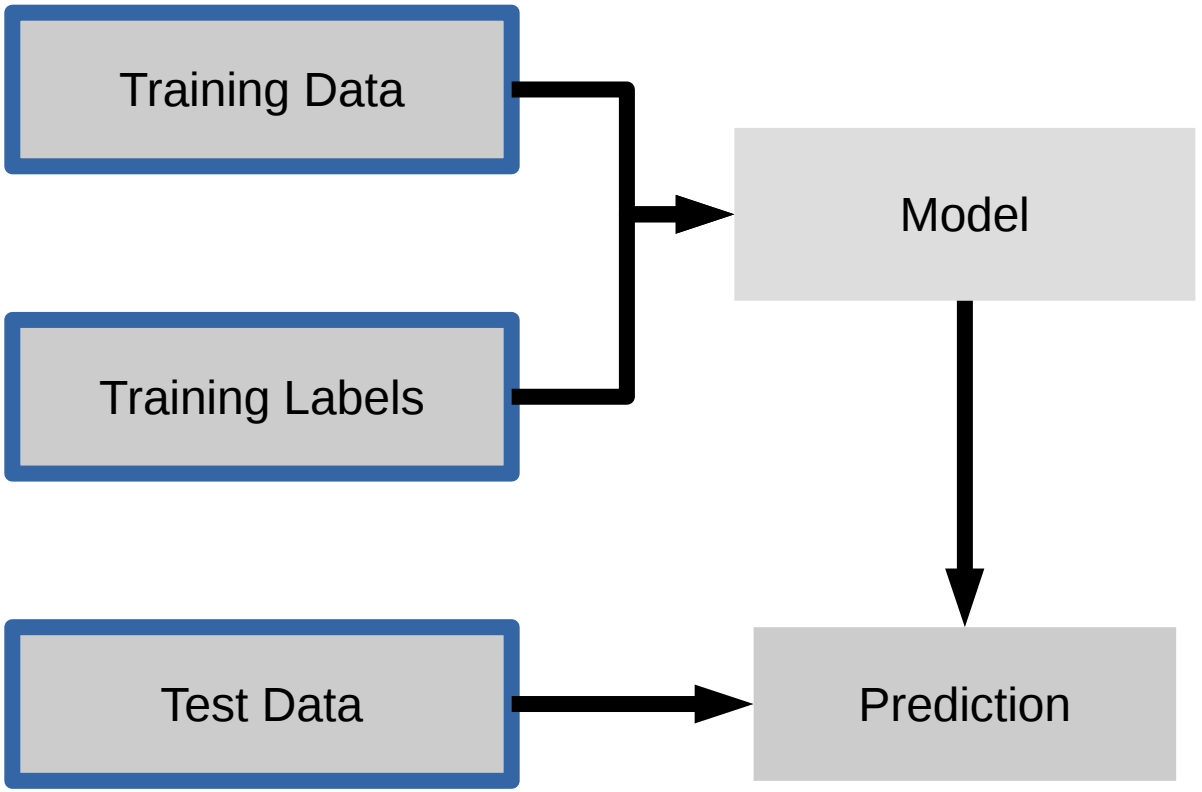


IPython Notebook:
Part 0 – Data Loading

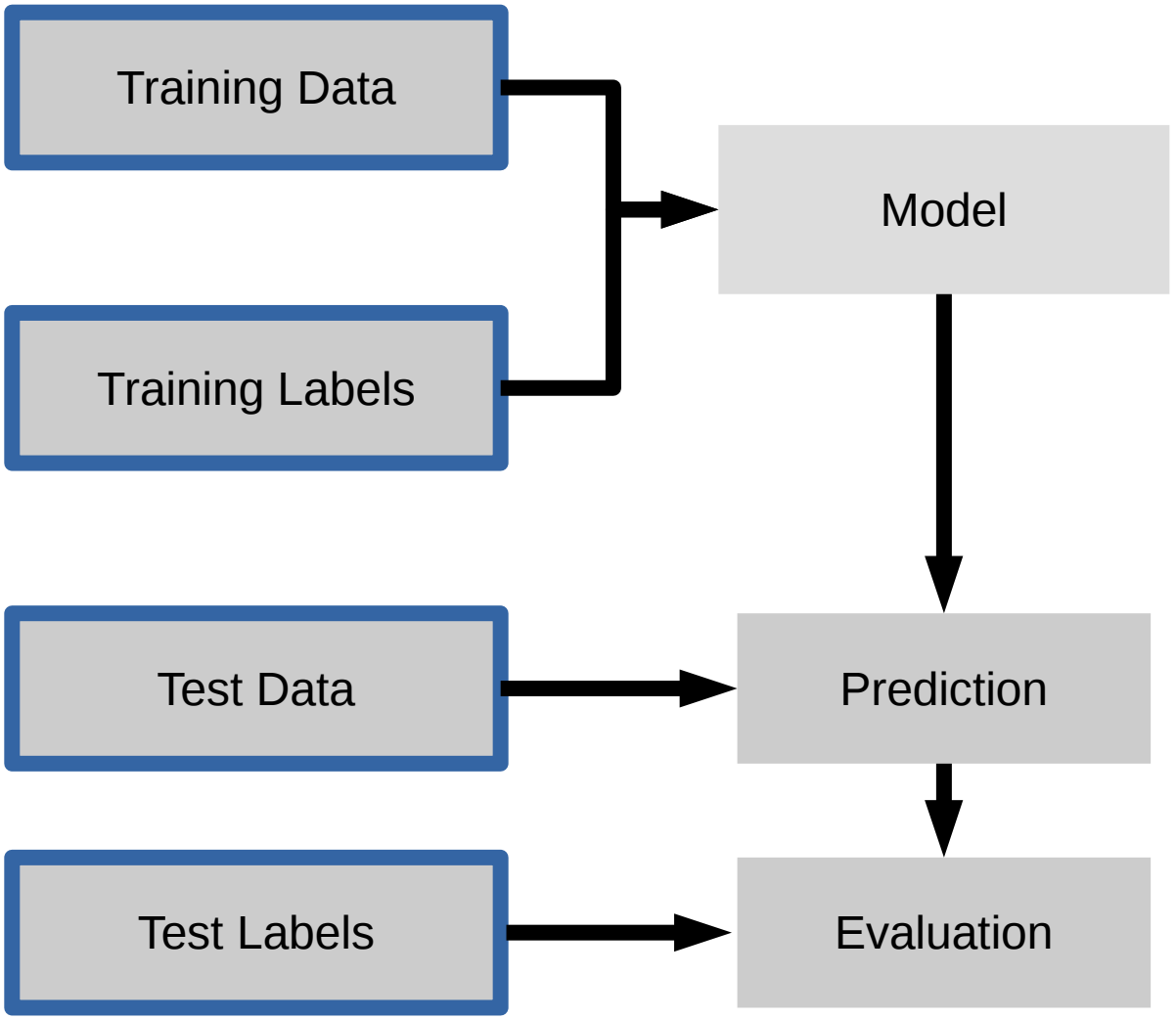
Supervised Machine Learning



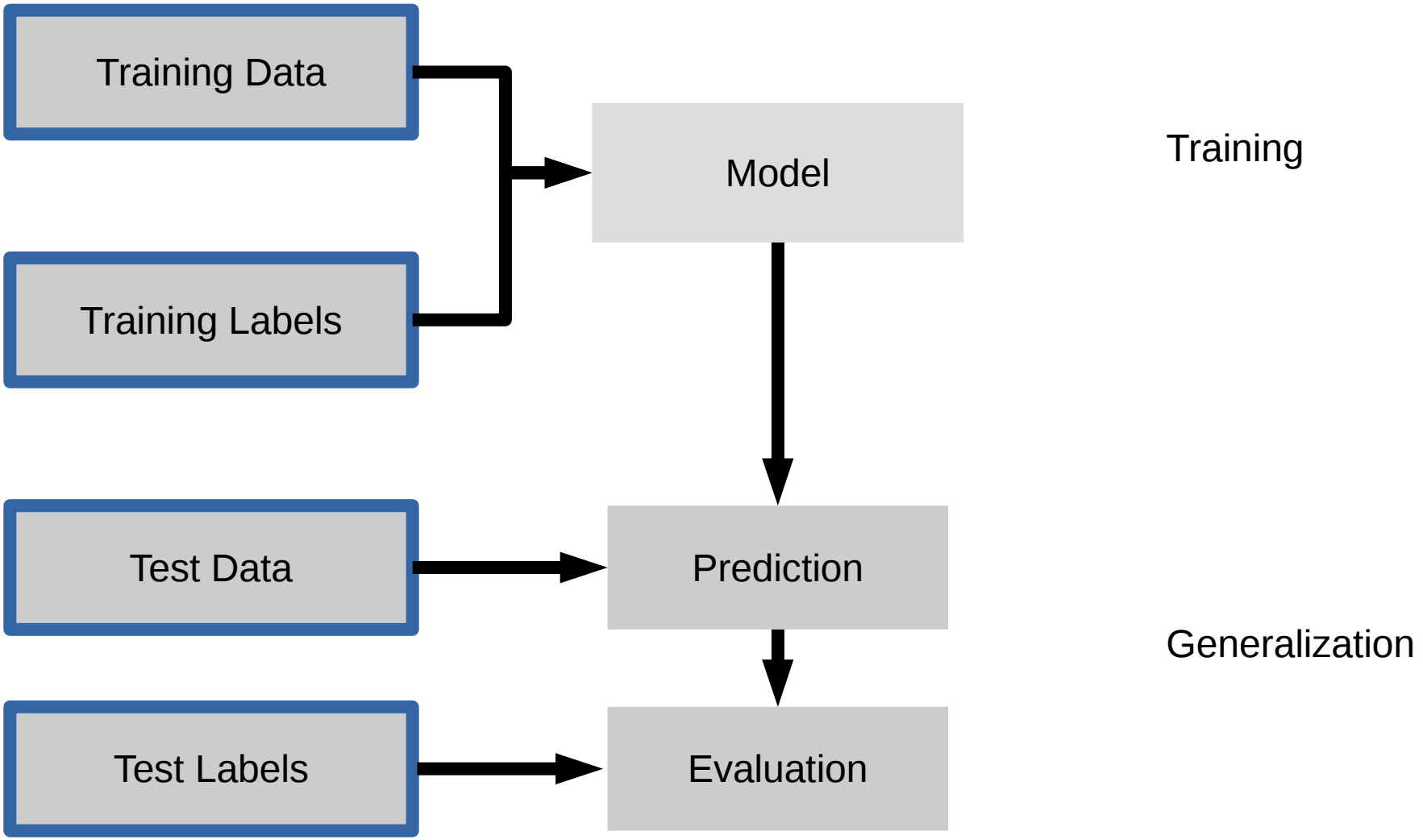
Supervised Machine Learning



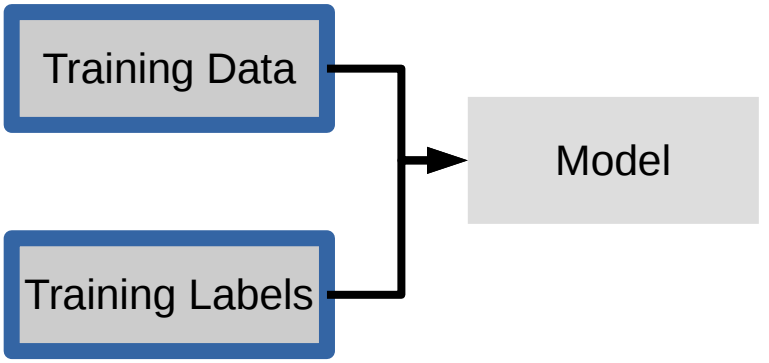
Supervised Machine Learning



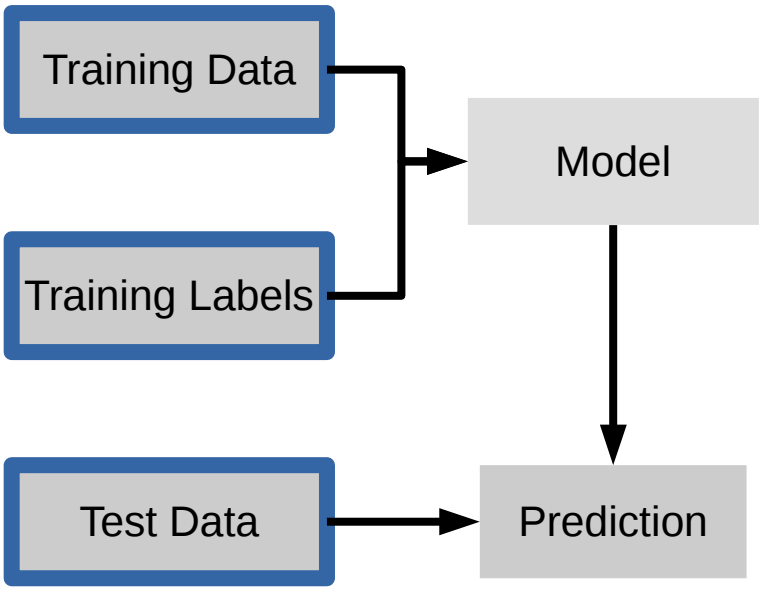
Supervised Machine Learning



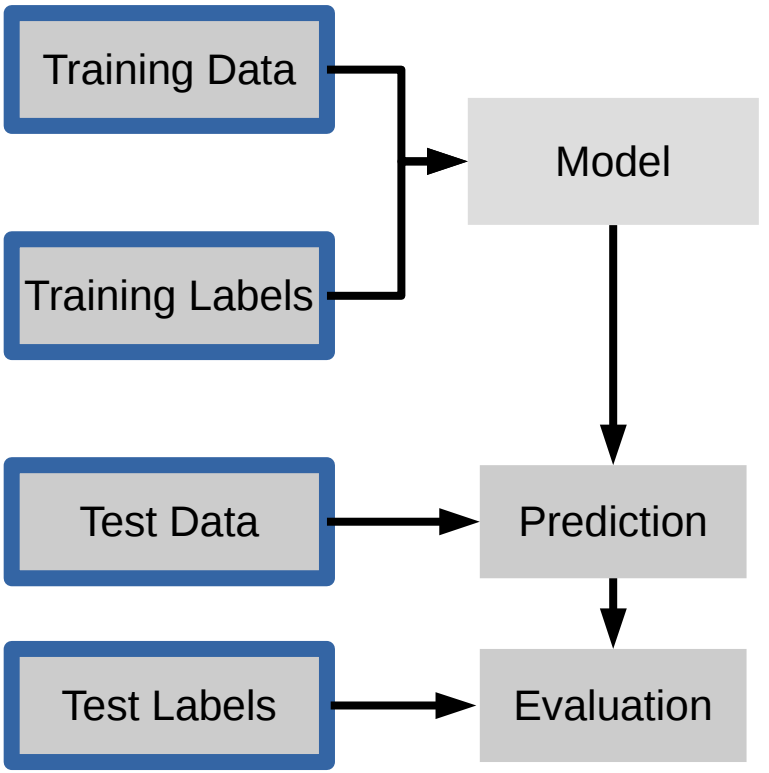
```
clf = RandomForestClassifier()

clf.fit(X_train, y_train)
```



```
clf = RandomForestClassifier()

clf.fit(X_train, y_train)

y_pred = clf.predict(X_test)
```

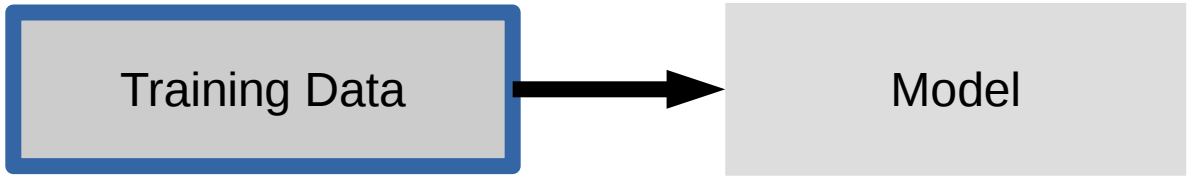


```
clf = RandomForestClassifier()

clf.fit(X_train, y_train)

y_pred = clf.predict(X_test)

clf.score(X_test, y_test)
```

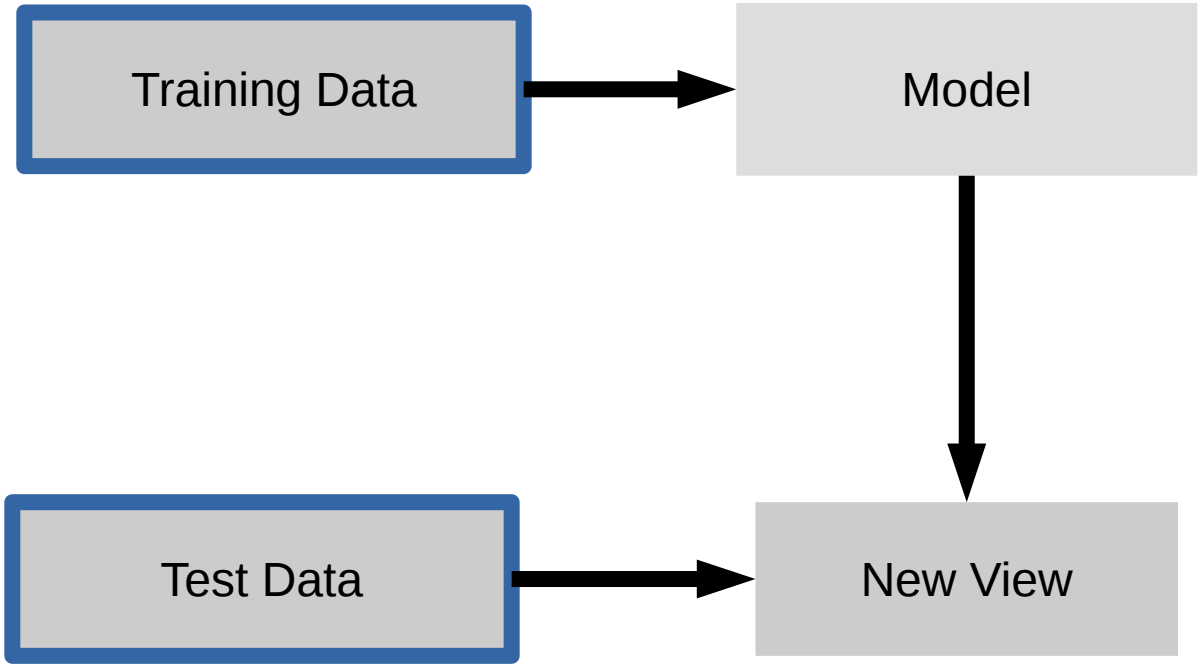


IPython Notebook:
Part 1 - Introduction to Scikit-learn

Unsupervised Machine Learning



Unsupervised Machine Learning

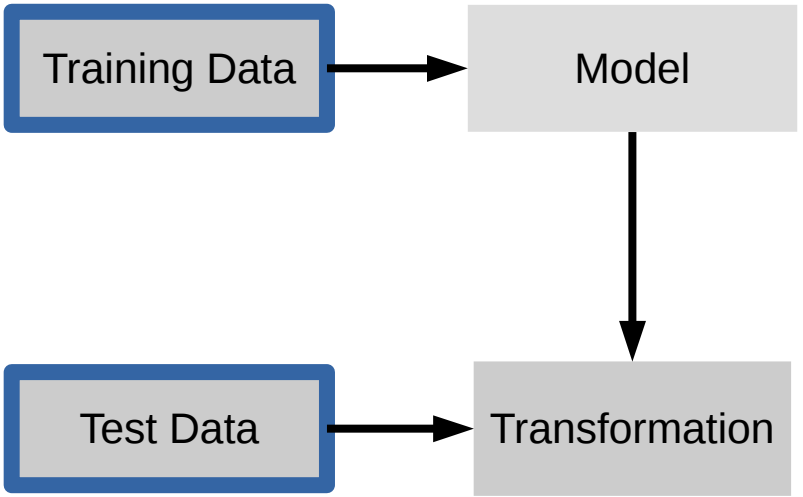


Unsupervised Transformations

```
pca = PCA()
```

```
pca.fit(X_train)
```

```
X_new = pca.transform(X_test)
```



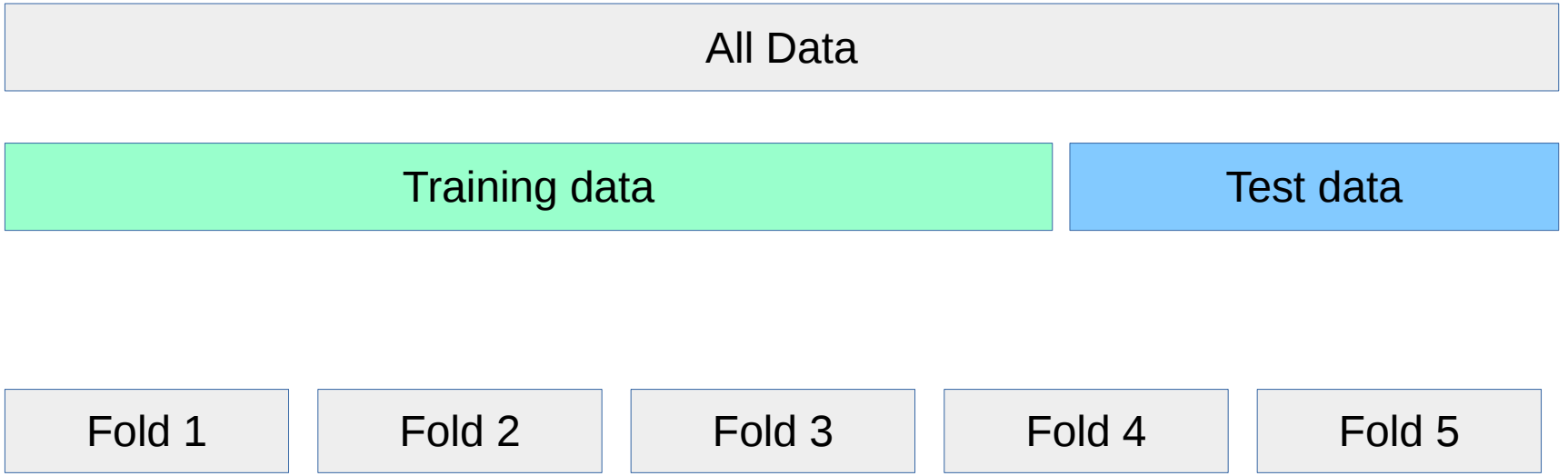
IPython Notebook:
Part 2 – Unsupervised Transformers

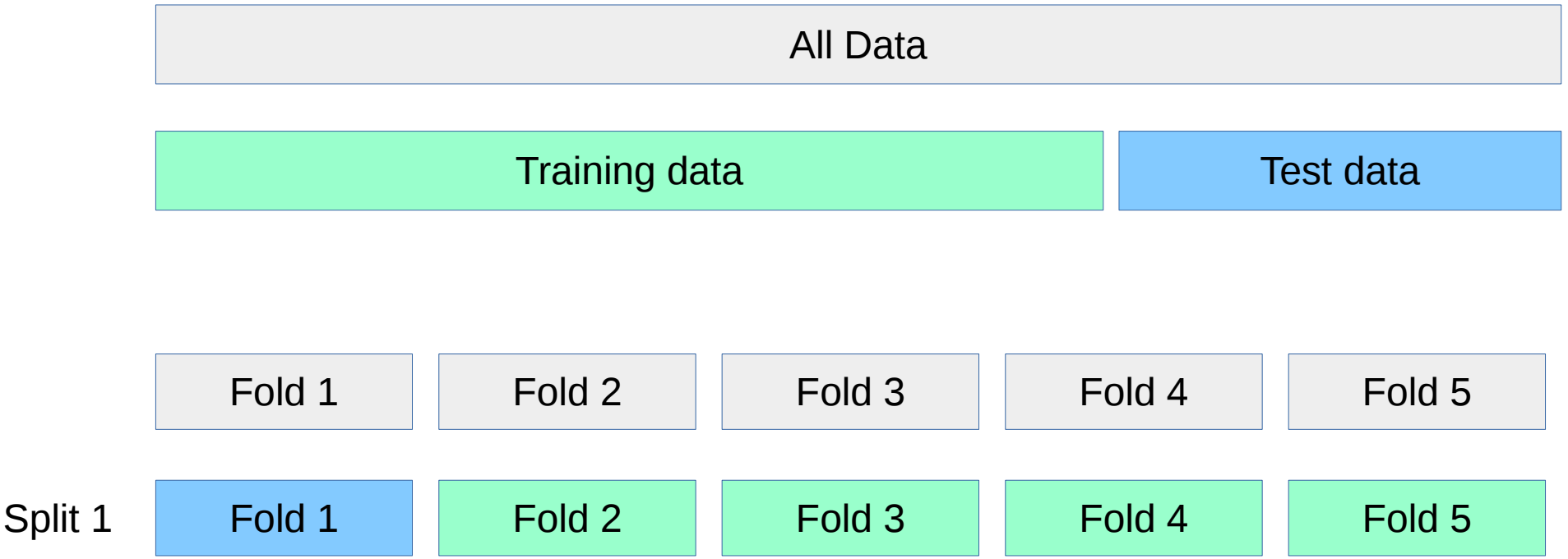
Basic API

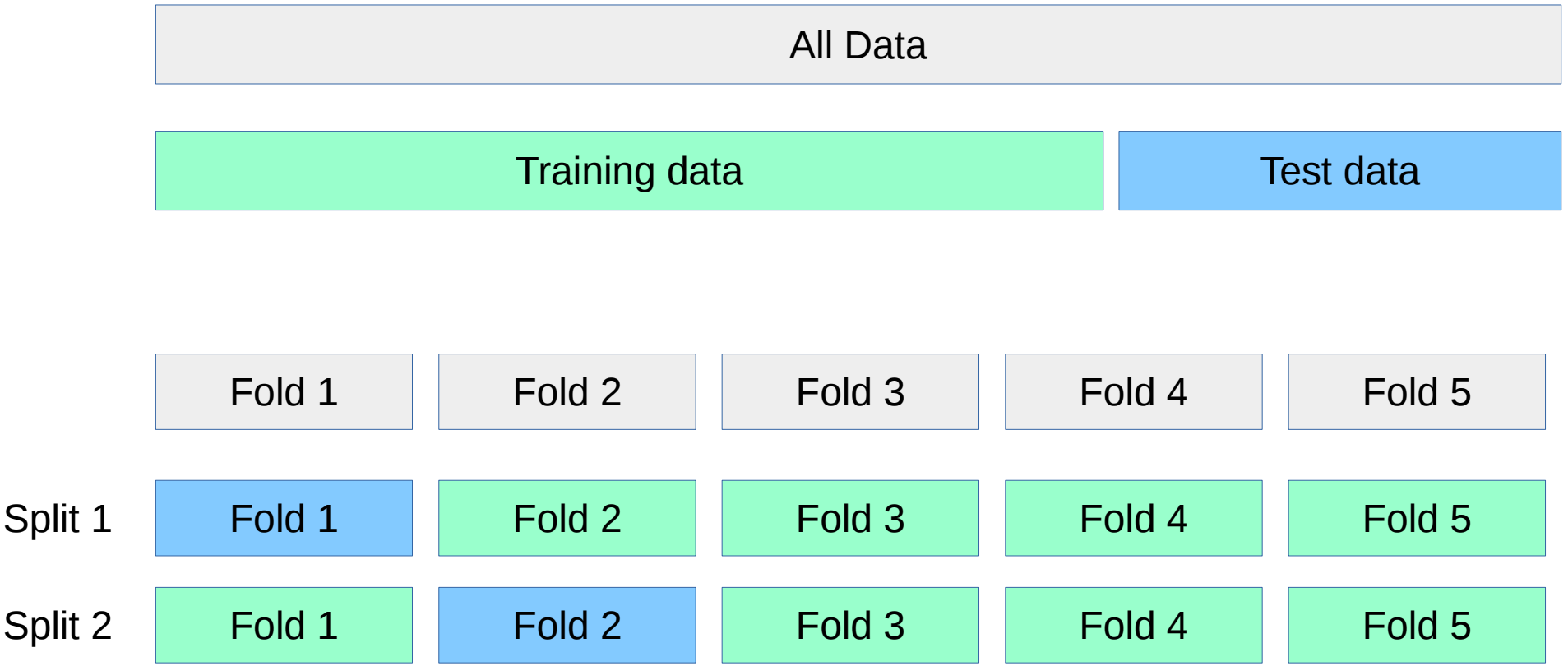
```
estimator.fit(X, [y])
```

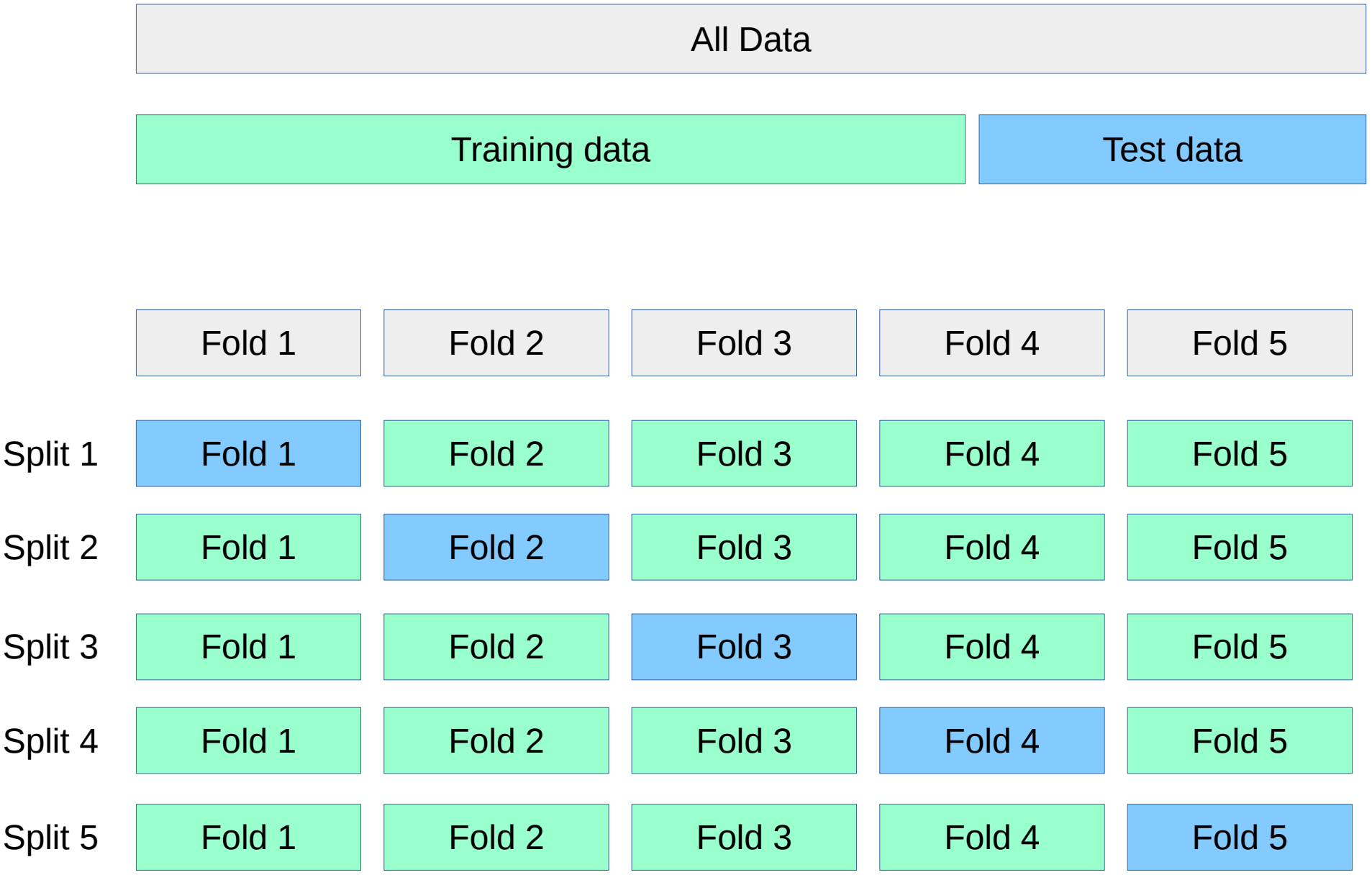
`estimator.predict`	`estimator.transform`
Classification	Preprocessing
Regression	Dimensionality reduction
Clustering	Feature selection
	Feature extraction


All Data
Training data
Test data


All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5

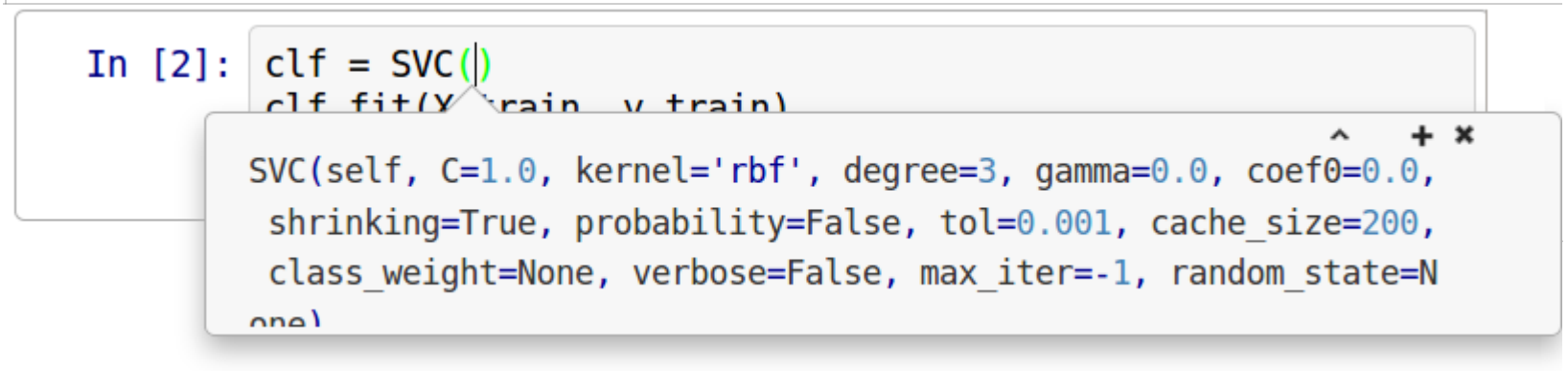

All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 1
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5


All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 1
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 2
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5

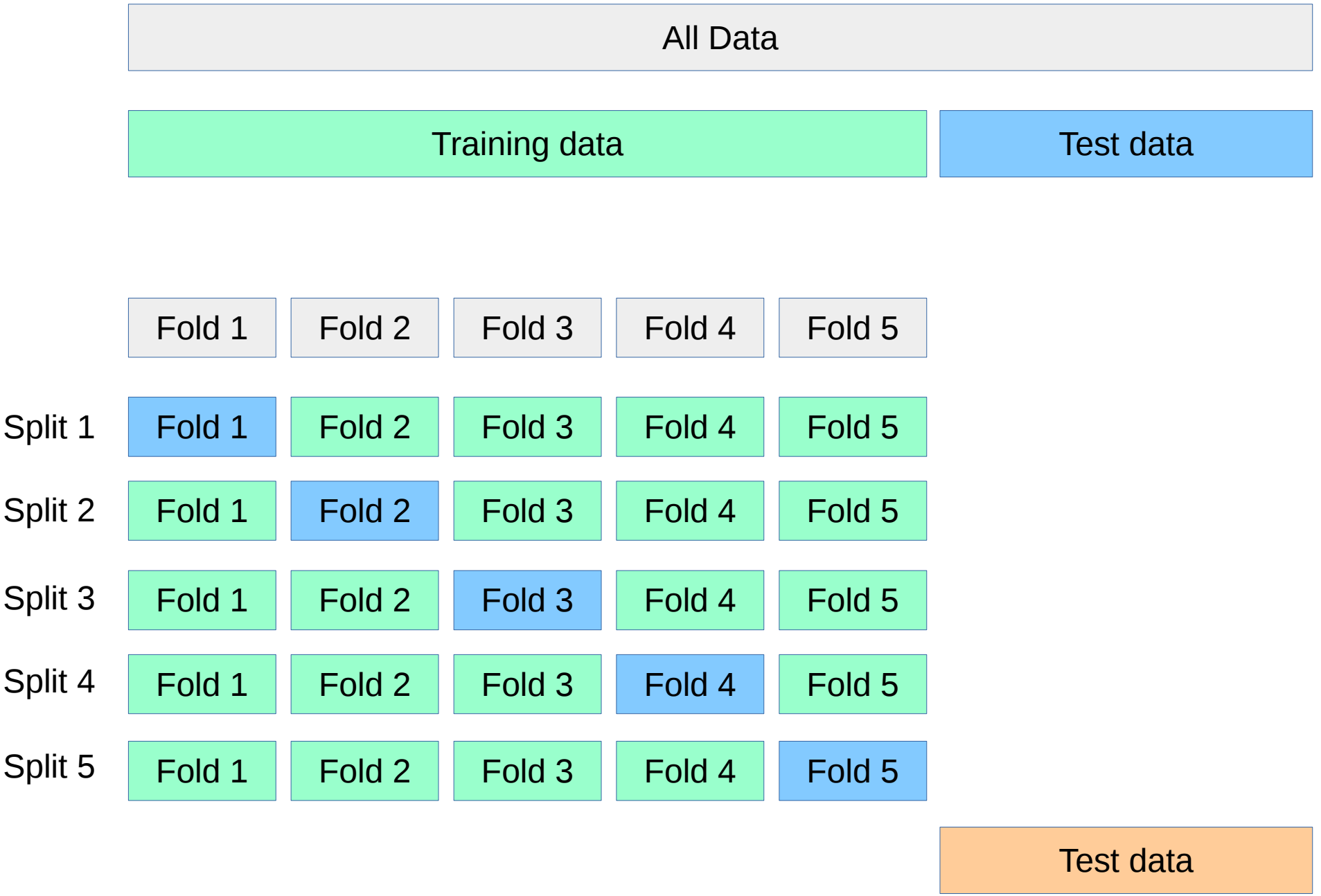

All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 1
Split 2
Split 3
Split 4
Split 5

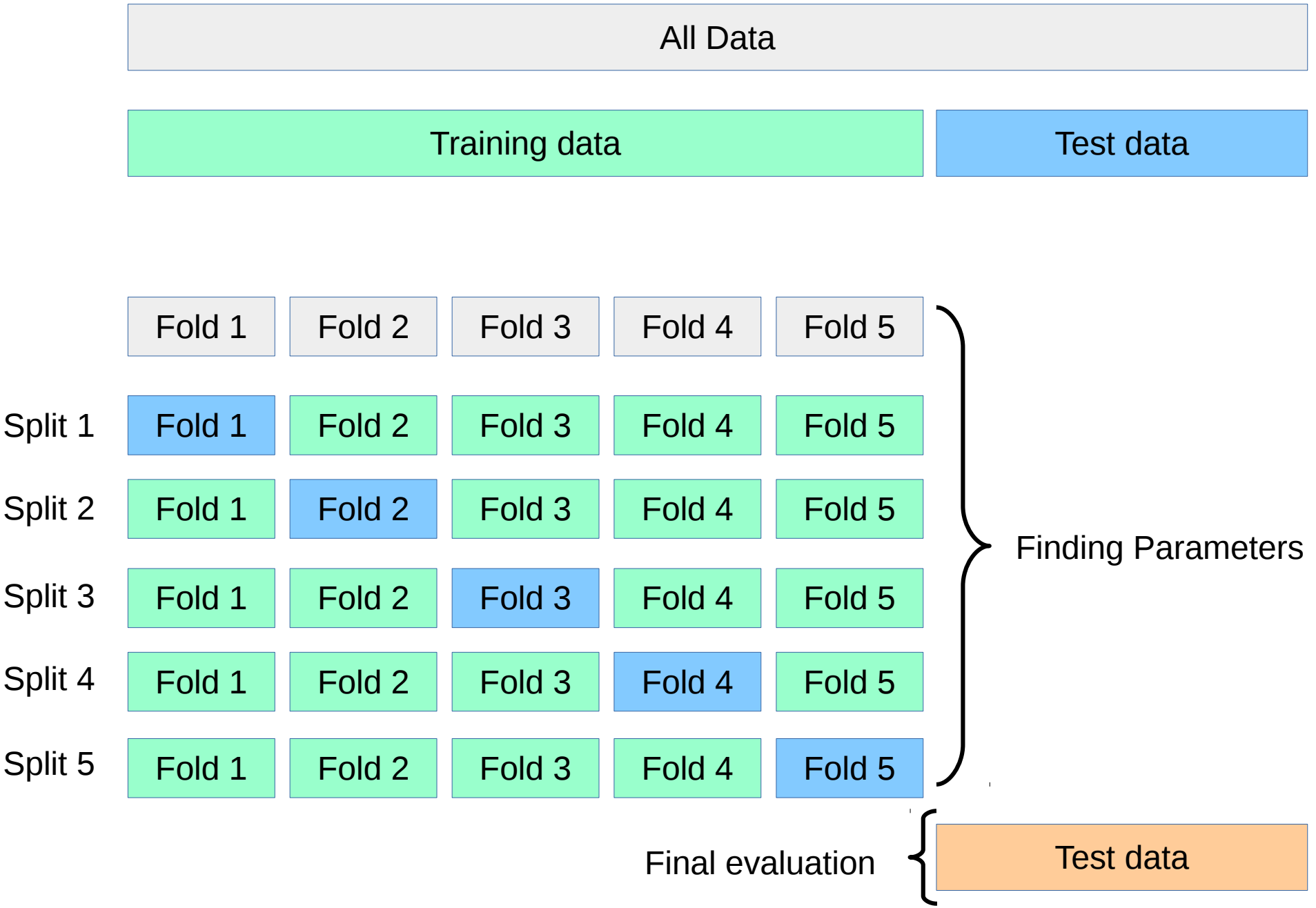
IPython Notebook:
Part 3 - Cross-validation

In [2]:
```
clf = SVC()
clf.fit(X_train, y_train)
y_pred = clf.predict(X_test)
```


In [2]:
clf = SVC()
SVC(self, C=1.0, kernel='rbf', degree=3, gamma=0.0, coef0=0.0,
shrinking=True, probability=False, tol=0.001, cache_size=200,
class_weight=None, verbose=False, max_iter=-1, random_state=N
one)


All Data
Training data
Test data


All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 1
Split 2
Split 3
Split 4
Split 5
Test data


All Data
Training data
Test data
Fold 1
Fold 2
Fold 3
Fold 4
Fold 5
Split 1
Split 2
Split 3
Split 4
Split 5
Finding Parameters
Final evaluation
Test data

SVC(C=0.001,
gamma=0.001)

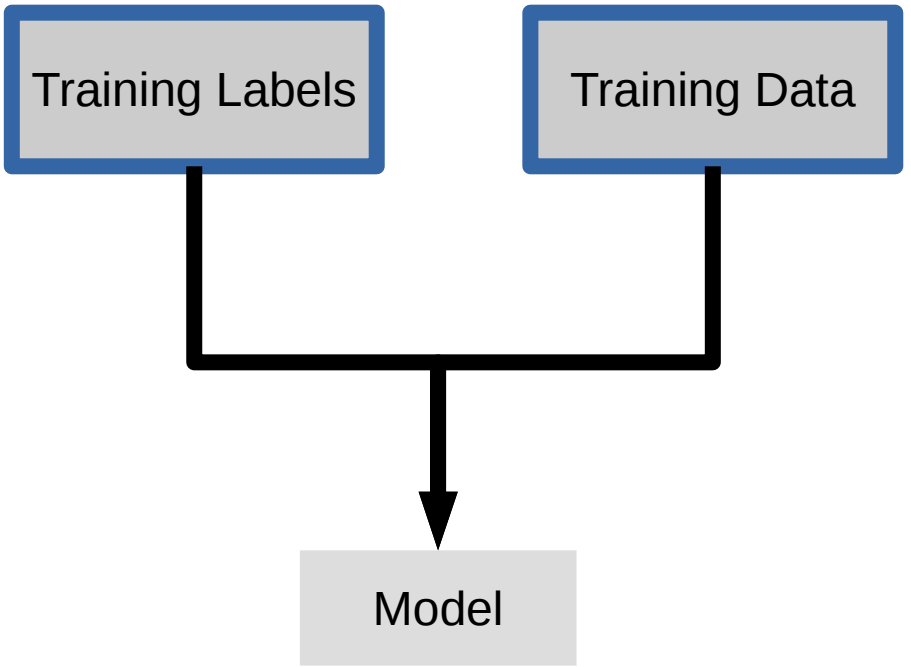
SVC(C=0.001, gamma=0.001)	SVC(C=0.01, gamma=0.001)	SVC(C=0.1, gamma=0.001)	SVC(C=1, gamma=0.001)	SVC(C=10, gamma=0.001)

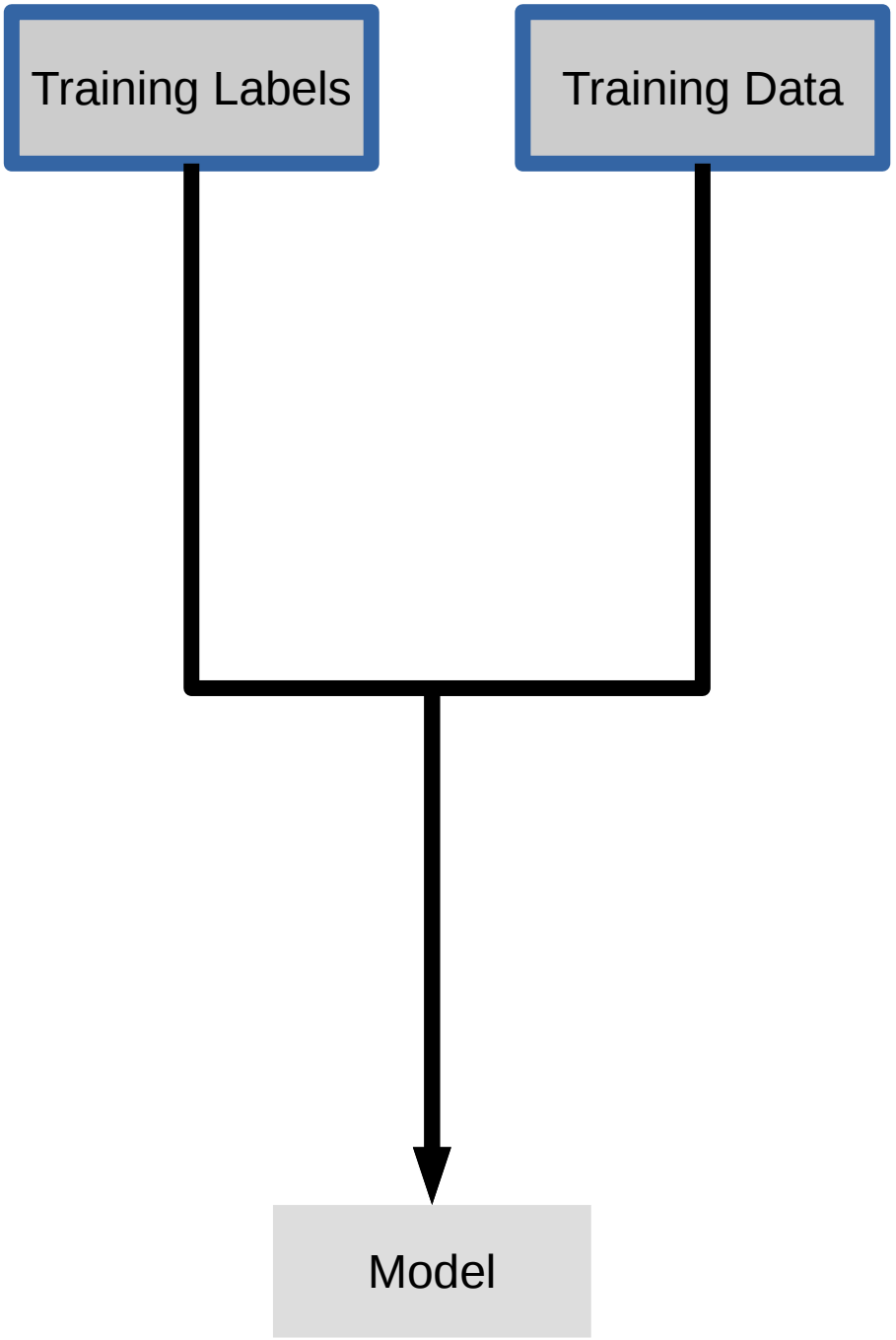
SVC(C=0.001, gamma=0.001)	SVC(C=0.01, gamma=0.001)	SVC(C=0.1, gamma=0.001)	SVC(C=1, gamma=0.001)	SVC(C=10, gamma=0.001)
SVC(C=0.001, gamma=0.01)	SVC(C=0.01, gamma=0.01)	SVC(C=0.1, gamma=0.01)	SVC(C=1, gamma=0.01)	SVC(C=10, gamma=0.01)

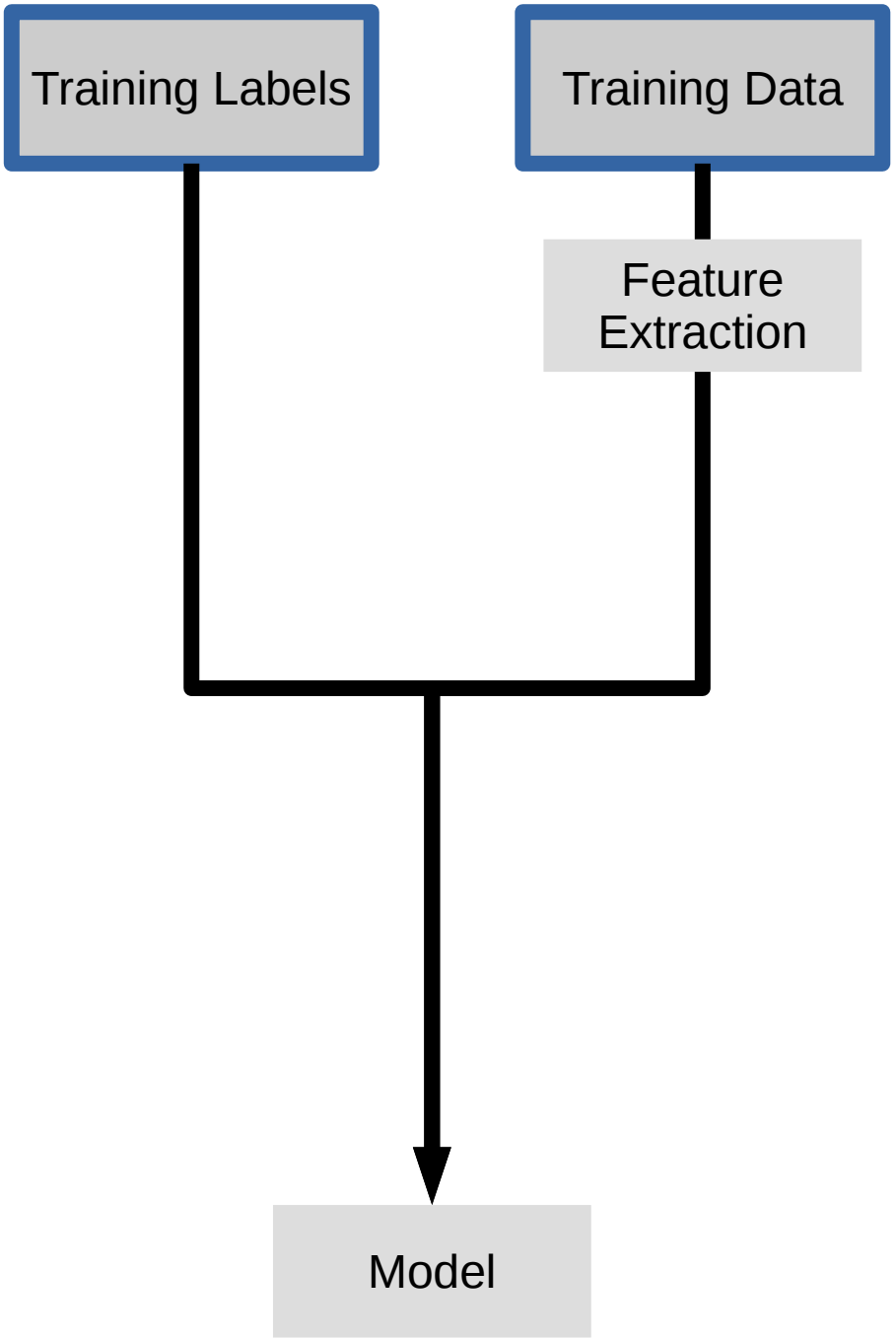
SVC(C=0.001, gamma=0.001)	SVC(C=0.01, gamma=0.001)	SVC(C=0.1, gamma=0.001)	SVC(C=1, gamma=0.001)	SVC(C=10, gamma=0.001)
SVC(C=0.001, gamma=0.01)	SVC(C=0.01, gamma=0.01)	SVC(C=0.1, gamma=0.01)	SVC(C=1, gamma=0.01)	SVC(C=10, gamma=0.01)
SVC(C=0.001, gamma=0.1)	SVC(C=0.01, gamma=0.1)	SVC(C=0.1, gamma=0.1)	SVC(C=1, gamma=0.1)	SVC(C=10, gamma=0.1)

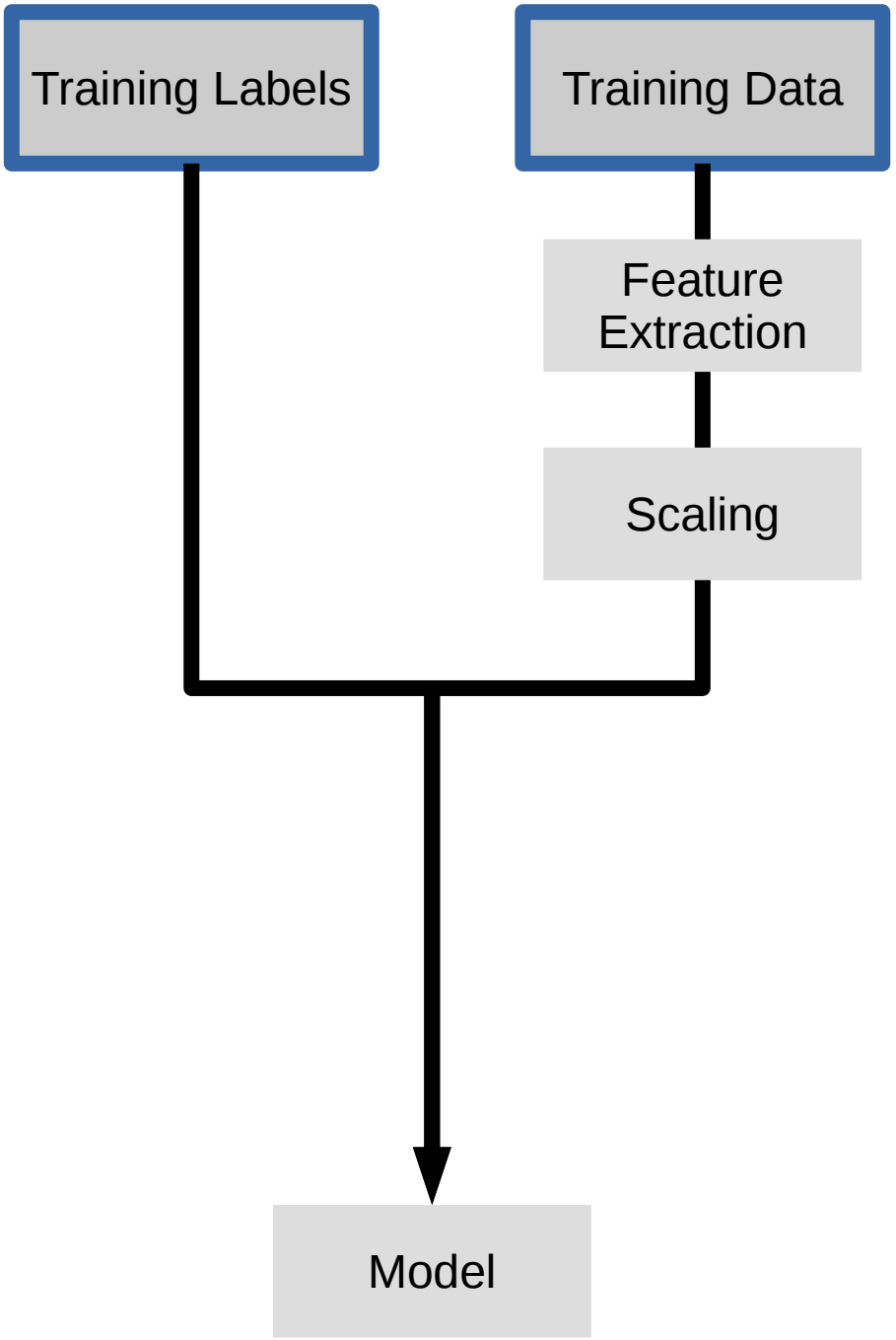
SVC(C=0.001, gamma=0.001)	SVC(C=0.01, gamma=0.001)	SVC(C=0.1, gamma=0.001)	SVC(C=1, gamma=0.001)	SVC(C=10, gamma=0.001)
SVC(C=0.001, gamma=0.01)	SVC(C=0.01, gamma=0.01)	SVC(C=0.1, gamma=0.01)	SVC(C=1, gamma=0.01)	SVC(C=10, gamma=0.01)
SVC(C=0.001, gamma=0.1)	SVC(C=0.01, gamma=0.1)	SVC(C=0.1, gamma=0.1)	SVC(C=1, gamma=0.1)	SVC(C=10, gamma=0.1)
SVC(C=0.001, gamma=1)	SVC(C=0.01, gamma=1)	SVC(C=0.1, gamma=1)	SVC(C=1, gamma=1)	SVC(C=10, gamma=1)
SVC(C=0.001, gamma=10)	SVC(C=0.01, gamma=10)	SVC(C=0.1, gamma=10)	SVC(C=1, gamma=10)	SVC(C=10, gamma=10)

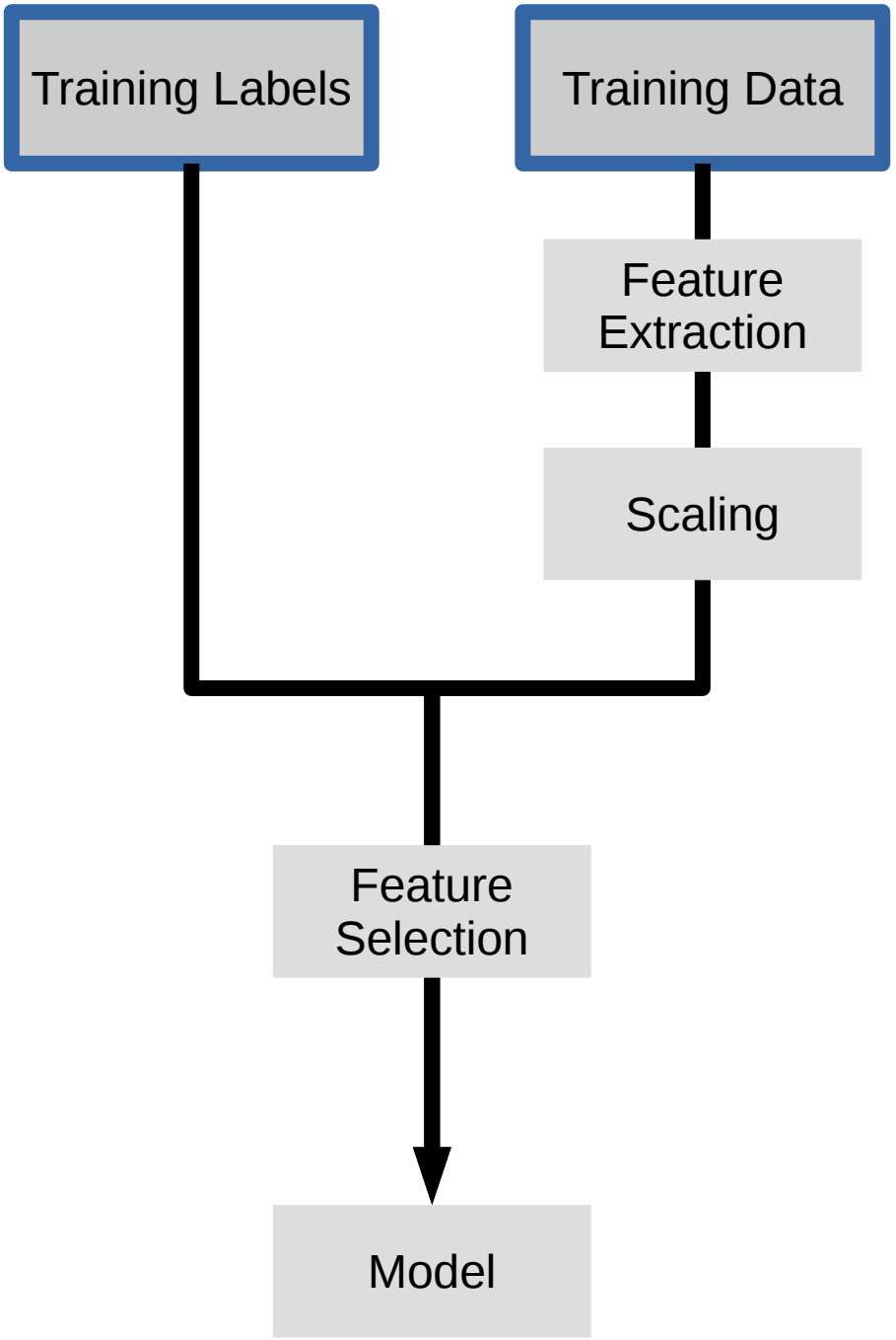
IPython Notebook:
Part 4 – Grid Searches

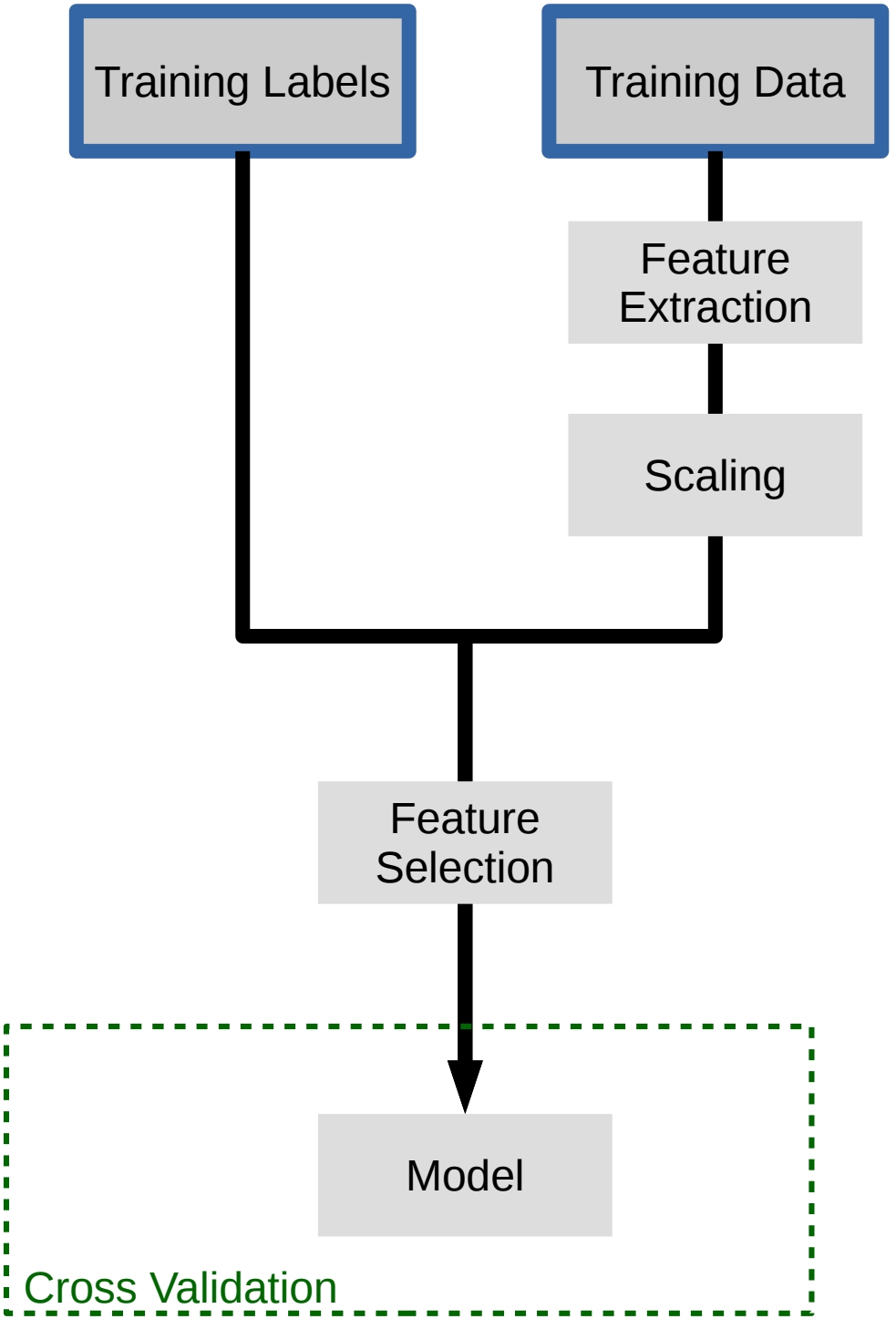

Training Labels
Training Data
Model

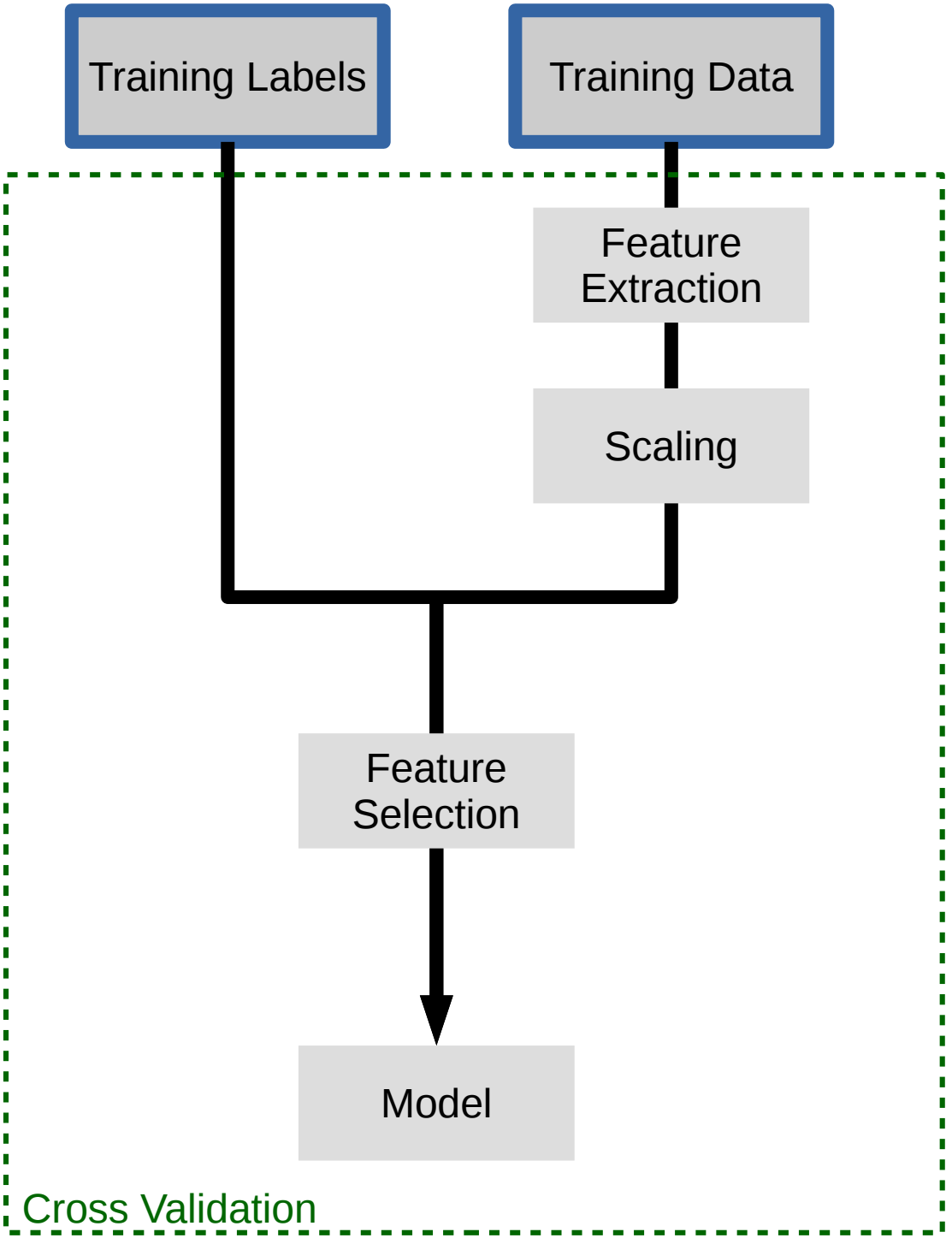

Training Labels
Training Data
Model


Training Labels
Training Data
Feature Extraction
Model


Training Labels
Training Data
Feature Extraction
Scaling
Model


Training Labels
Training Data
Feature Extraction
Scaling
Feature Selection
Model

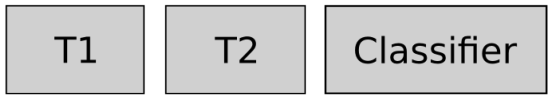

Training Labels
Training Data
Feature Extraction
Scaling
Feature Selection
Model
Cross Validation


Training Labels
Training Data
Feature Extraction
Scaling
Feature Selection
Model
Cross Validation

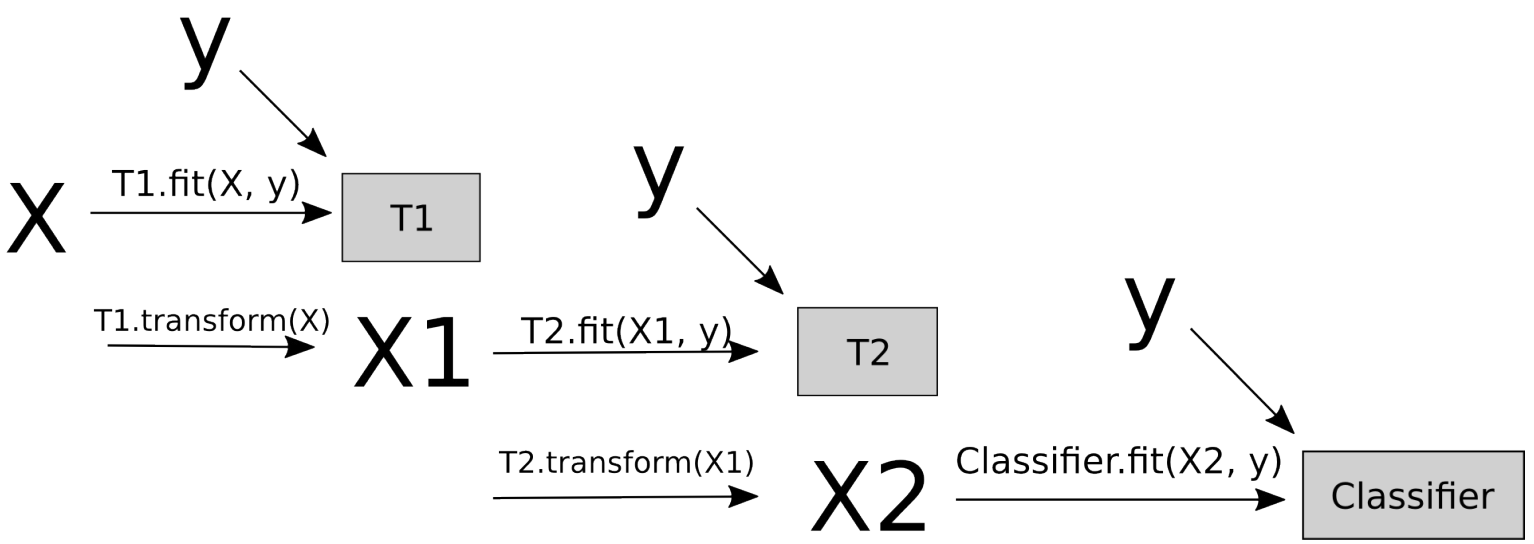
Pipelines

Pipelines

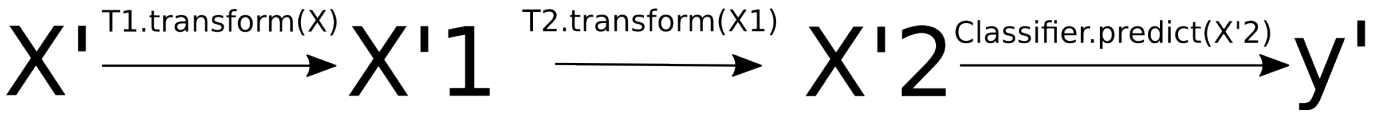
pipe = make_pipeline(T1(), T2(), Classifier())



pipe.fit(X, y)



pipe.predict(X)



IPython Notebook:
Part 5 - Preprocessing and Pipelines

Do cross-validation over all steps jointly.
Keep a separate test set until the very end.

Sample application: Sentiment Analysis

IMDB Movie Reviews Data

Review:
One of the worst movies I've ever rented. Sorry it had one of my favorite actors on it (Travolta) in a nonsense role. In fact, anything made sense in this movie.

Who can say there was true love between Eddy and Maureen? Don't you remember the beginning of the movie ?

Is she so lovely? Ask her daughters. I don't think so.

Label: negative

Training data: 12500 positive, 12500 negative

Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`

Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

tokenizer

```
['this', 'is', 'how', 'you', 'get', 'ants']
```

Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

tokenizer

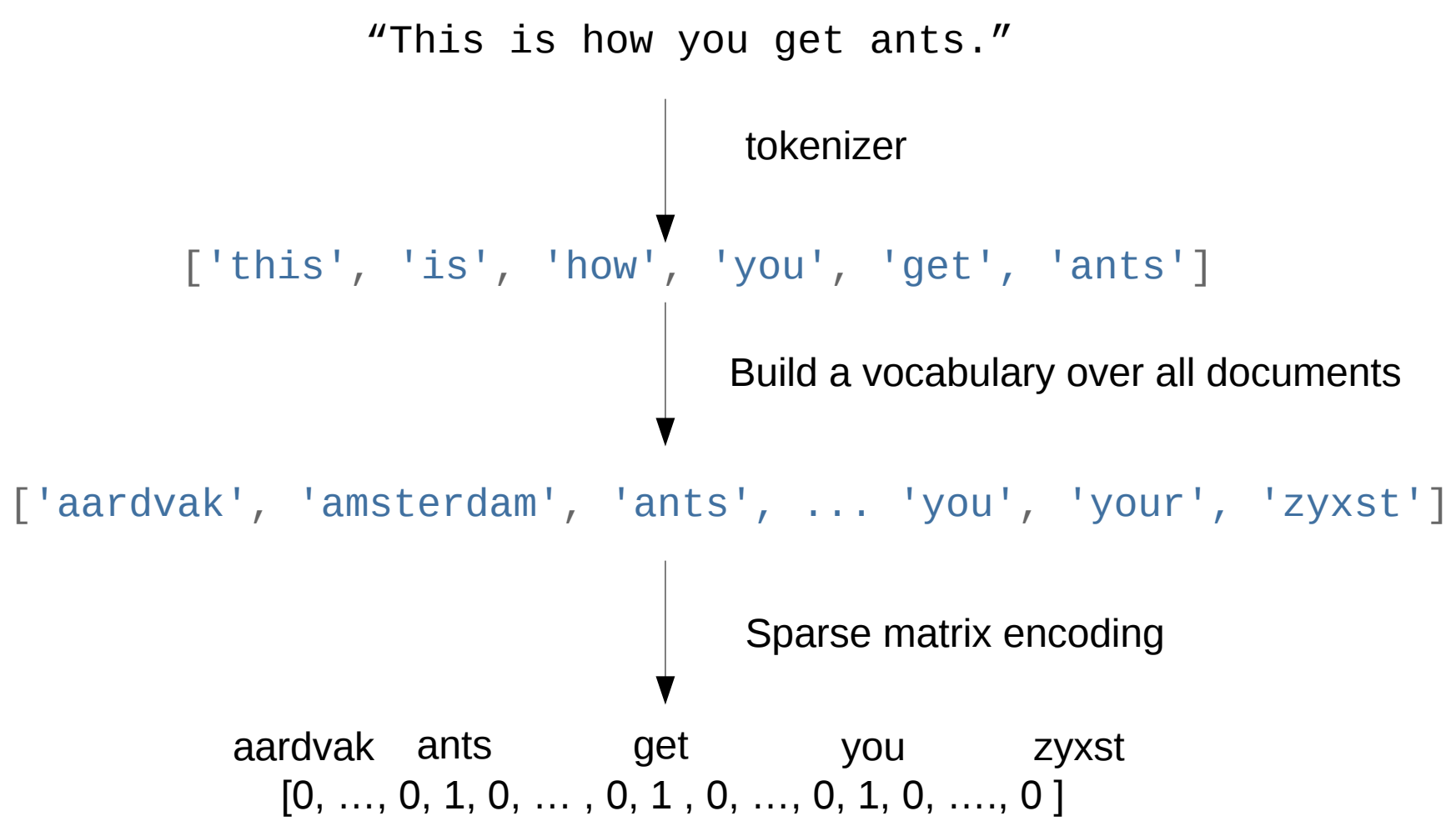
`['this', 'is', 'how', 'you', 'get', 'ants']`

Build a vocabulary over all documents

`['aardvak', 'amsterdam', 'ants', ... 'you', 'your', 'zyxst']`

Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`



N-grams (unigrams and bigrams)

`CountVectorizer` / `TfidfVectorizer`

N-grams (unigrams and bigrams)

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

N-grams (unigrams and bigrams)

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

Unigram tokenizer

```
['this', 'is', 'how', 'you', 'get', 'ants']
```

N-grams (unigrams and bigrams)

`CountVectorizer / TfidfVectorizer`

`“This is how you get ants.”`

Unigram tokenizer

`['this', 'is', 'how', 'you', 'get', 'ants']`

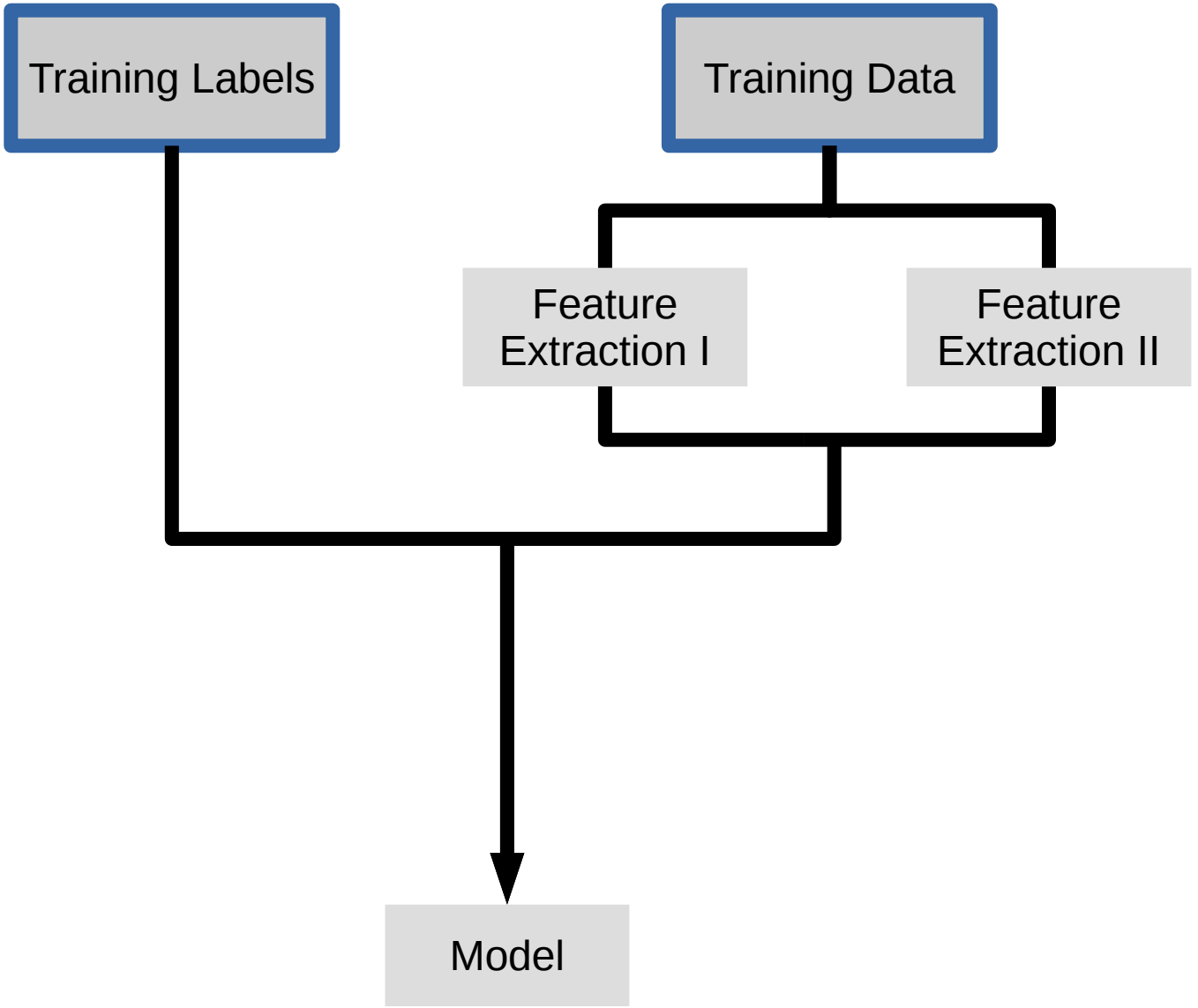
`“This is how you get ants.”`

Bigram tokenizer

`['this is', 'is how', 'how you', 'you get', 'get ants']`

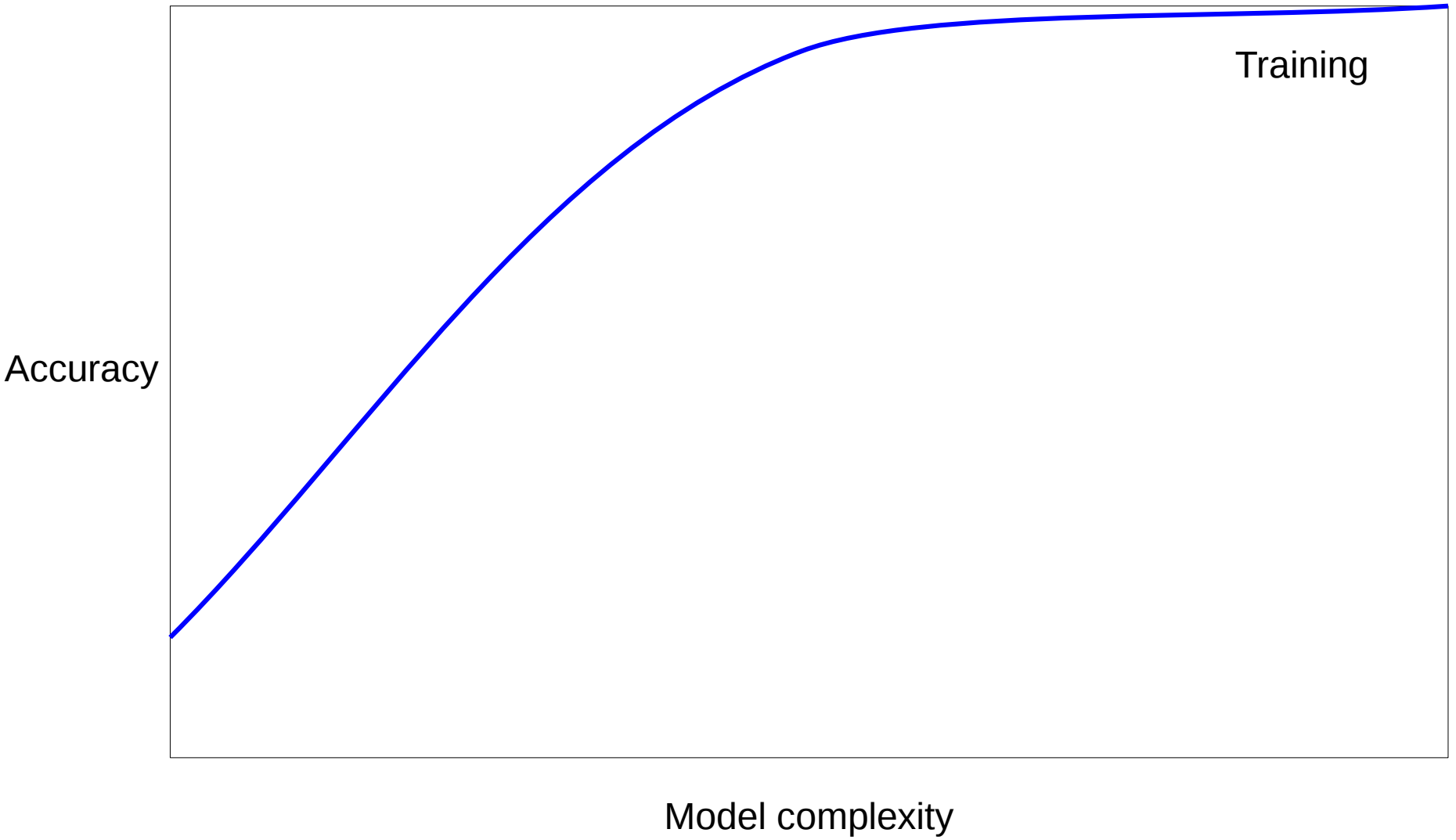
IPython Notebook:
Part 6 - Working With Text Data

Feature Union

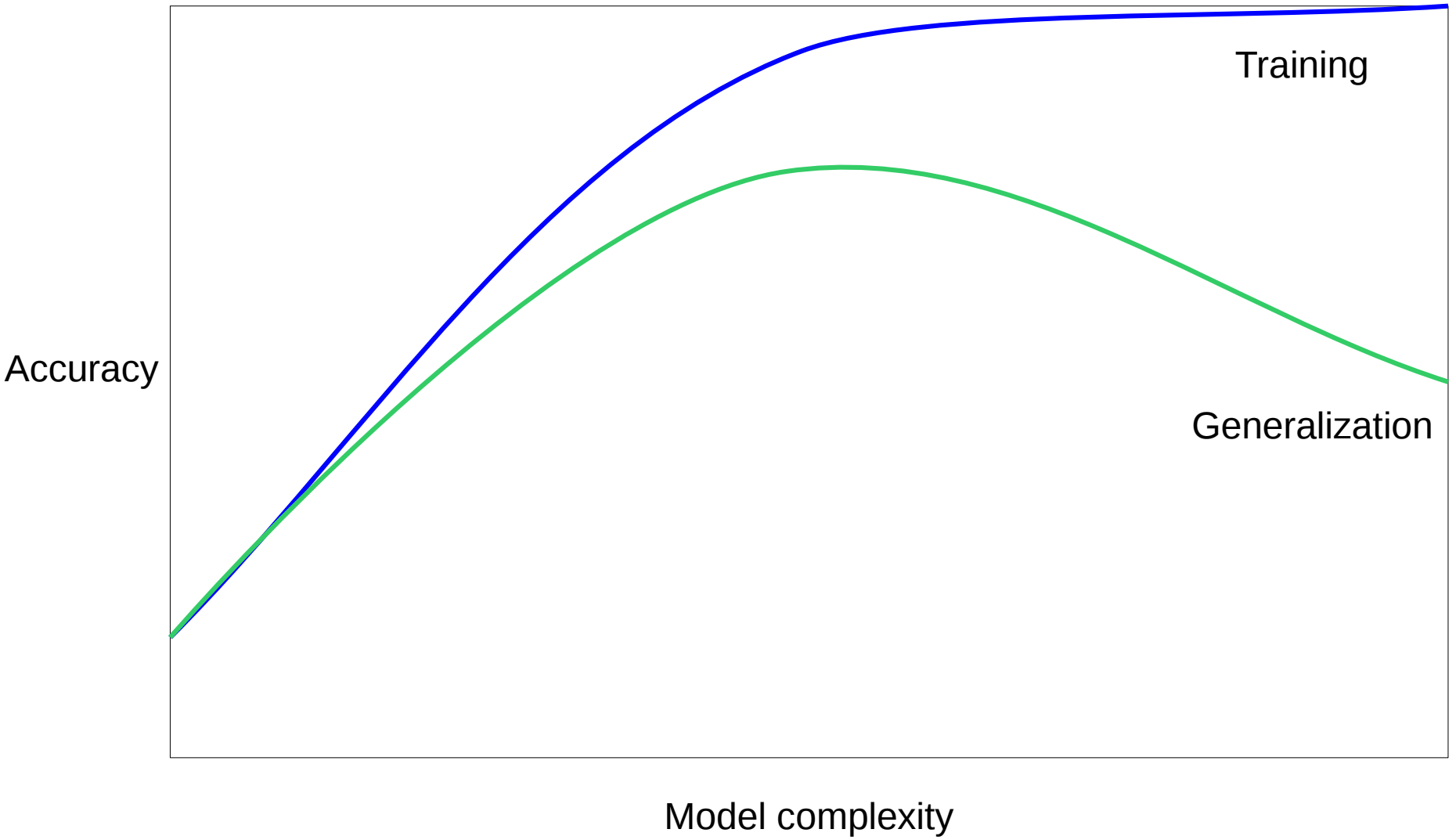


IPython Notebook:
Part 7 – FeatureUnion

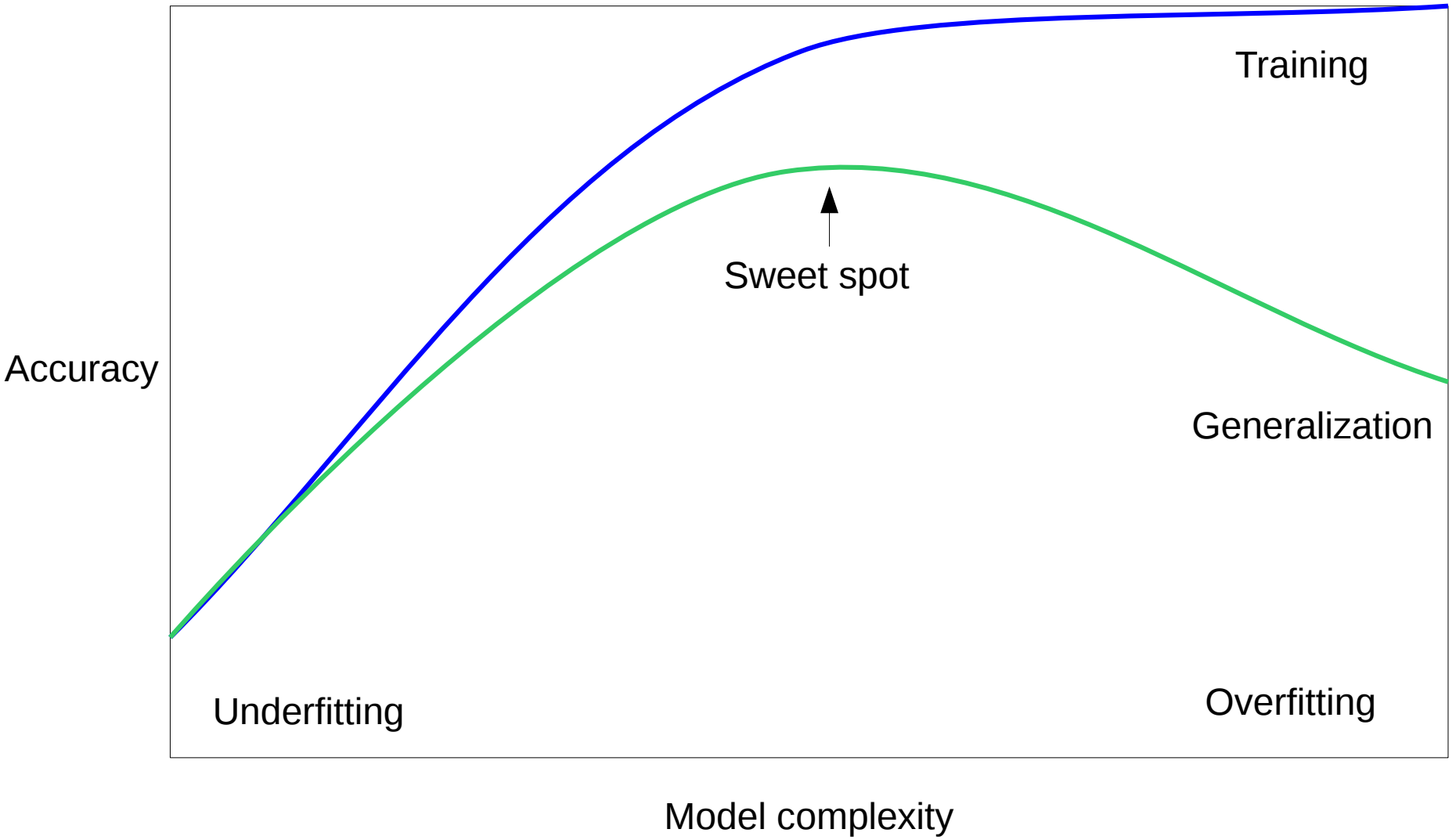
Overfitting and Underfitting



Overfitting and Underfitting



Overfitting and Underfitting

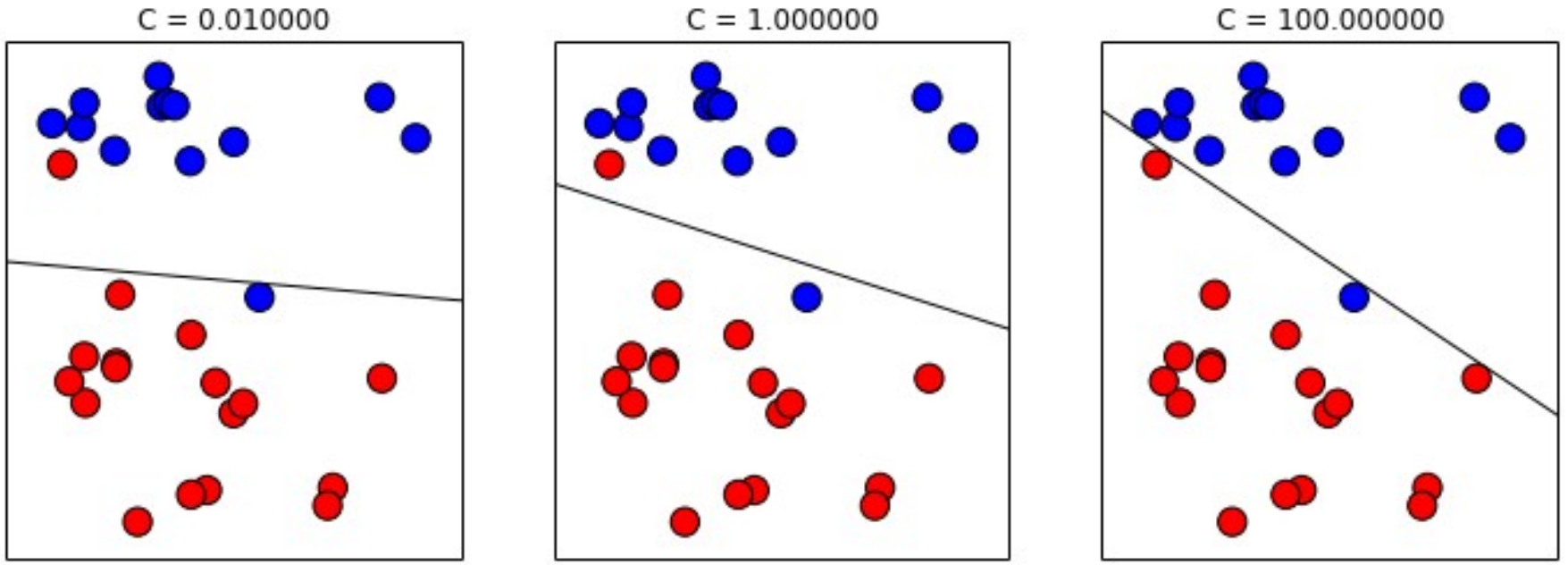


Linear SVM

$$\hat{y} = \text{sign}(w_0 + \sum_i w_i x_i)$$

Linear SVM

$$\hat{y} = \text{sign}(w_0 + \sum_i w_i x_i)$$



(RBF) Kernel SVM

$$\hat{y} = \text{sign}(\alpha_0 + \sum_j \alpha_j y_j k(\mathbf{x^{(j)}}, \mathbf{x}))$$

(RBF) Kernel SVM

$$\hat{y} = \text{sign}(\alpha_0 + \sum_j \alpha_j y_j k(\mathbf{x^{(j)}}, \mathbf{x}))$$

$$k(\mathbf{x}, \mathbf{x}') = \exp(-\gamma ||\mathbf{x} - \mathbf{x}'||^2)$$

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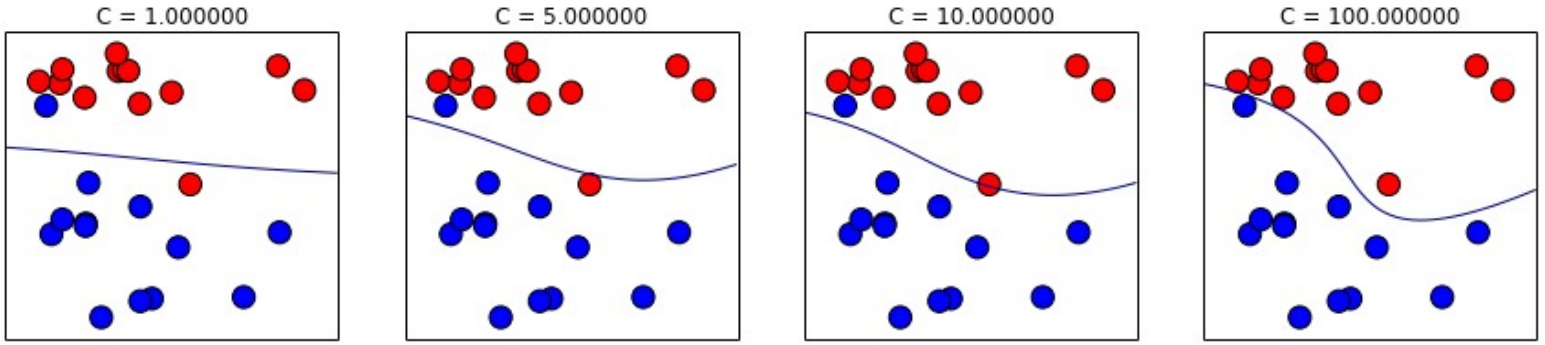

(RBF) Kernel SVM

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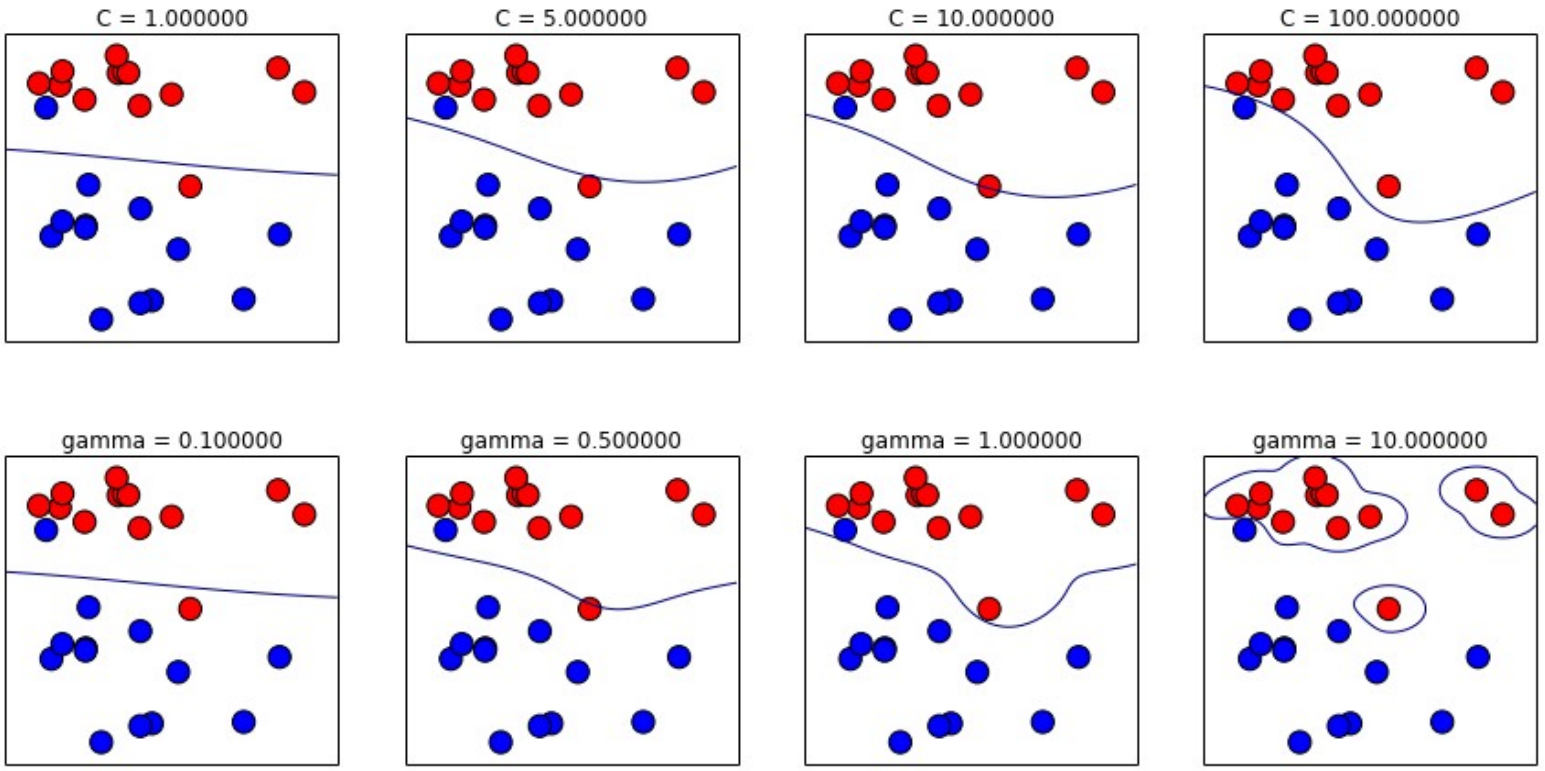
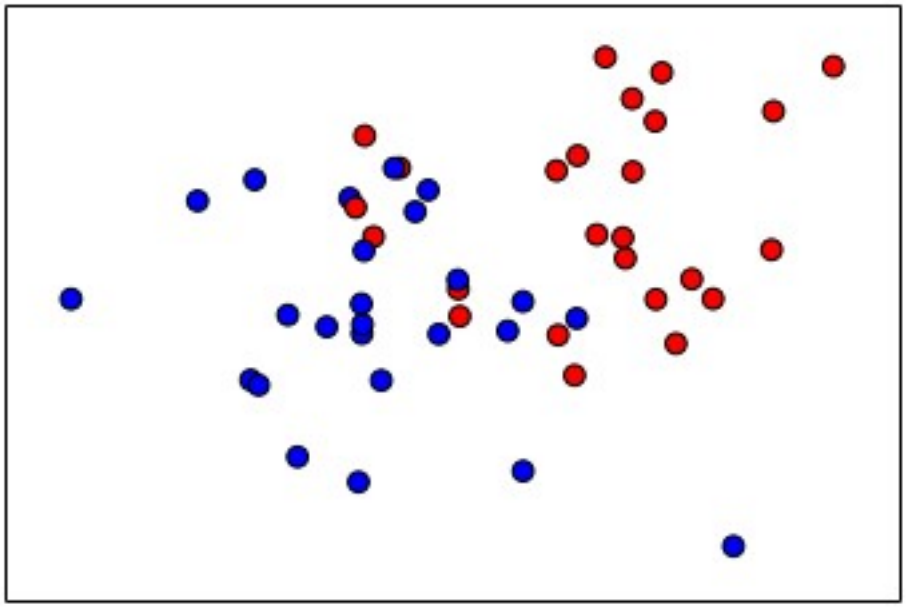
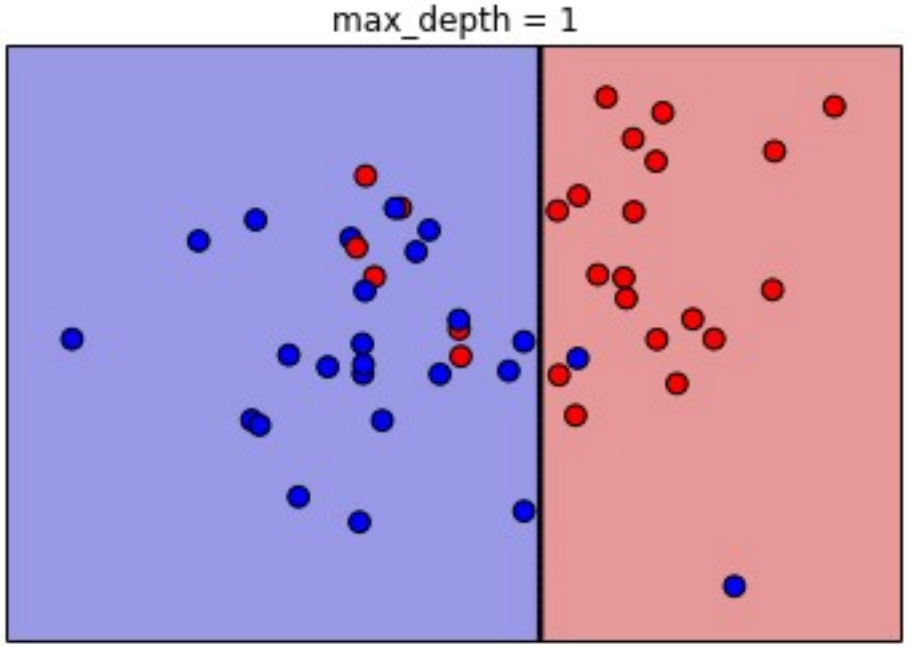
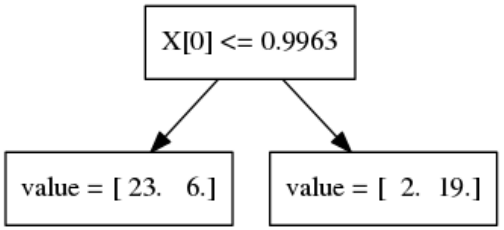


Decision Trees

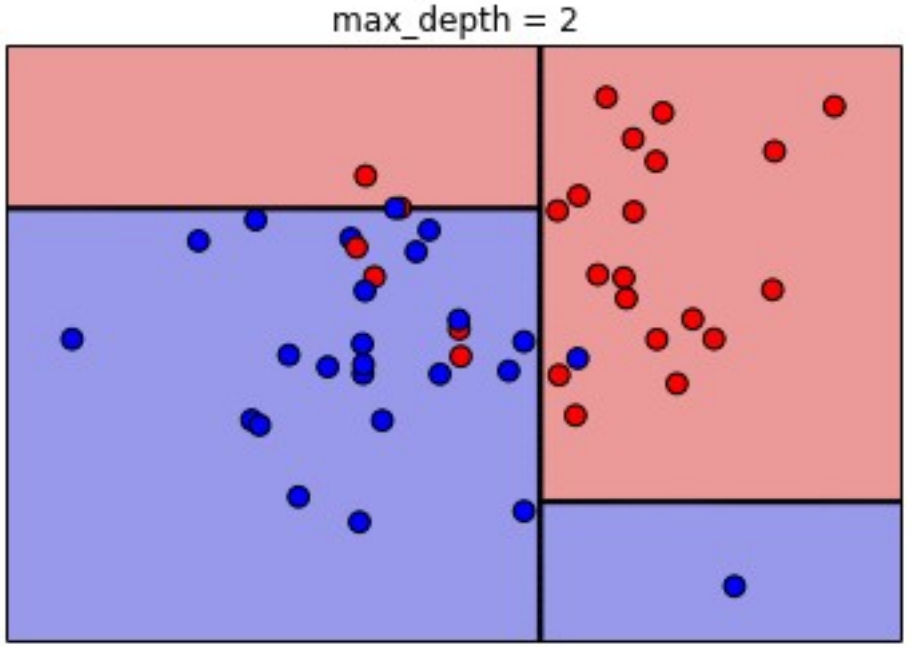


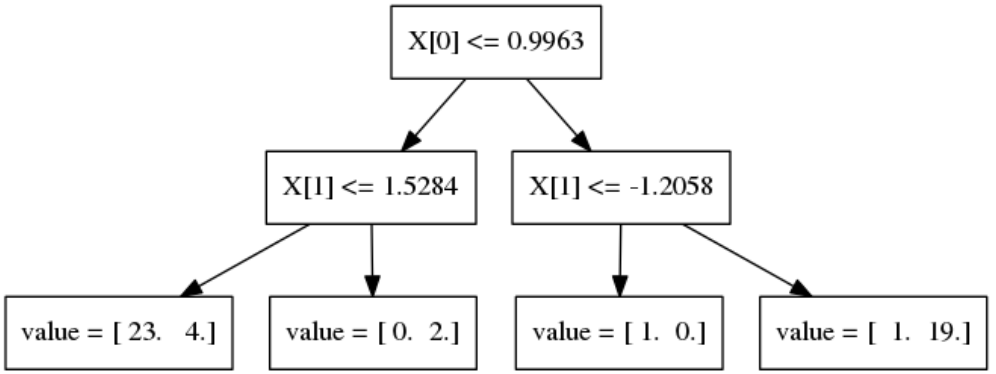
Decision Trees



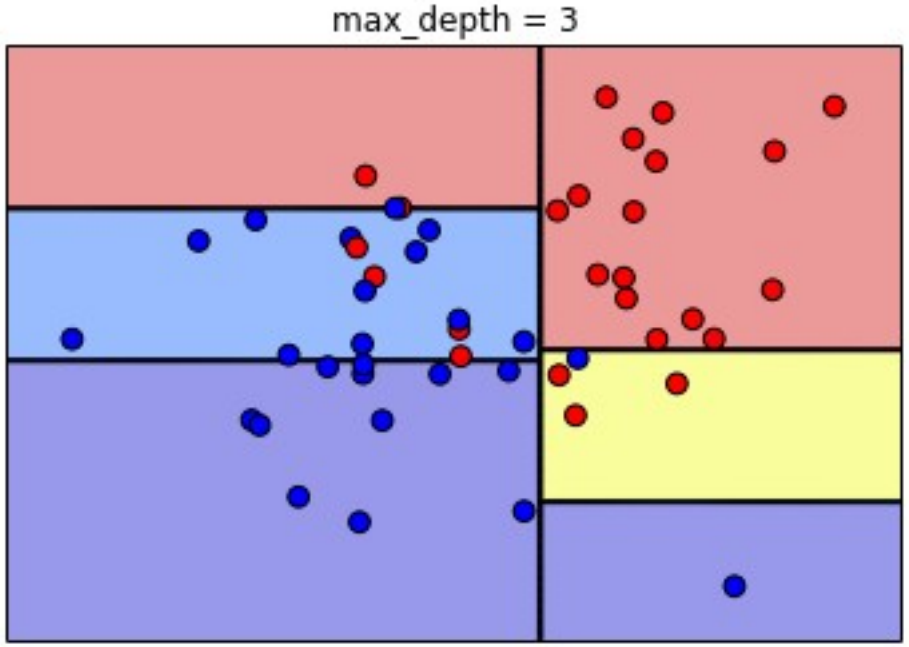


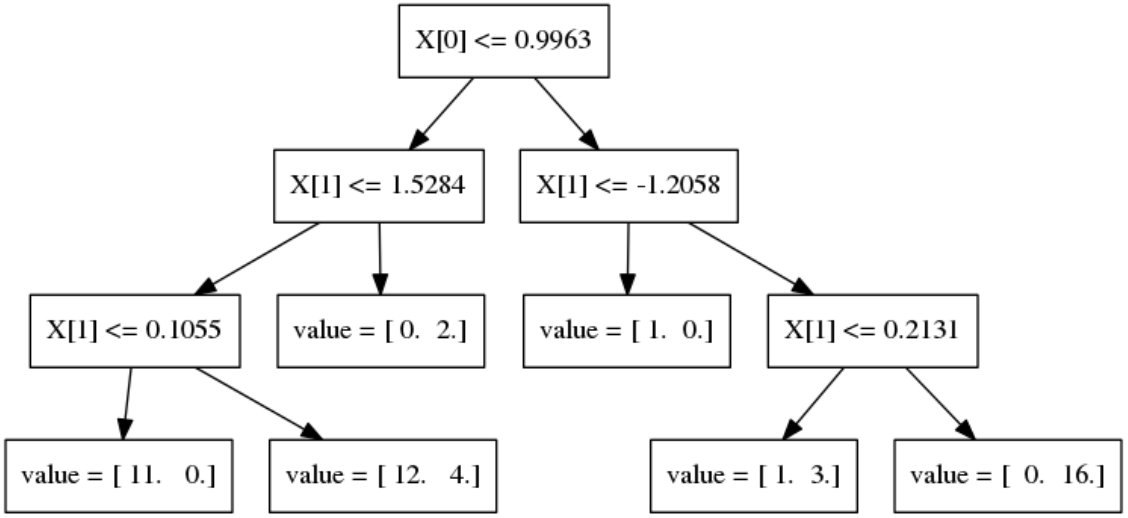
Decision Trees



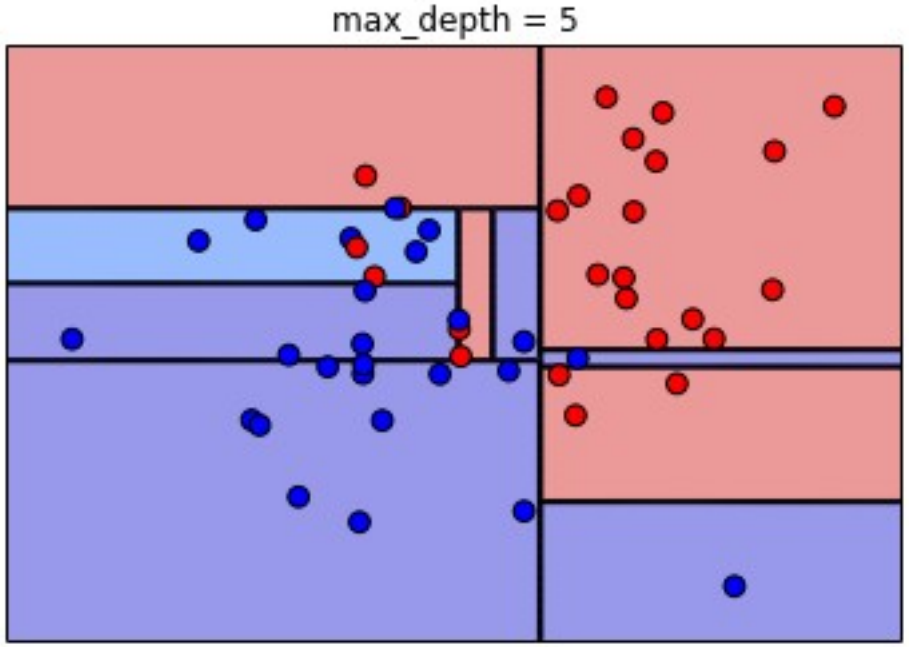


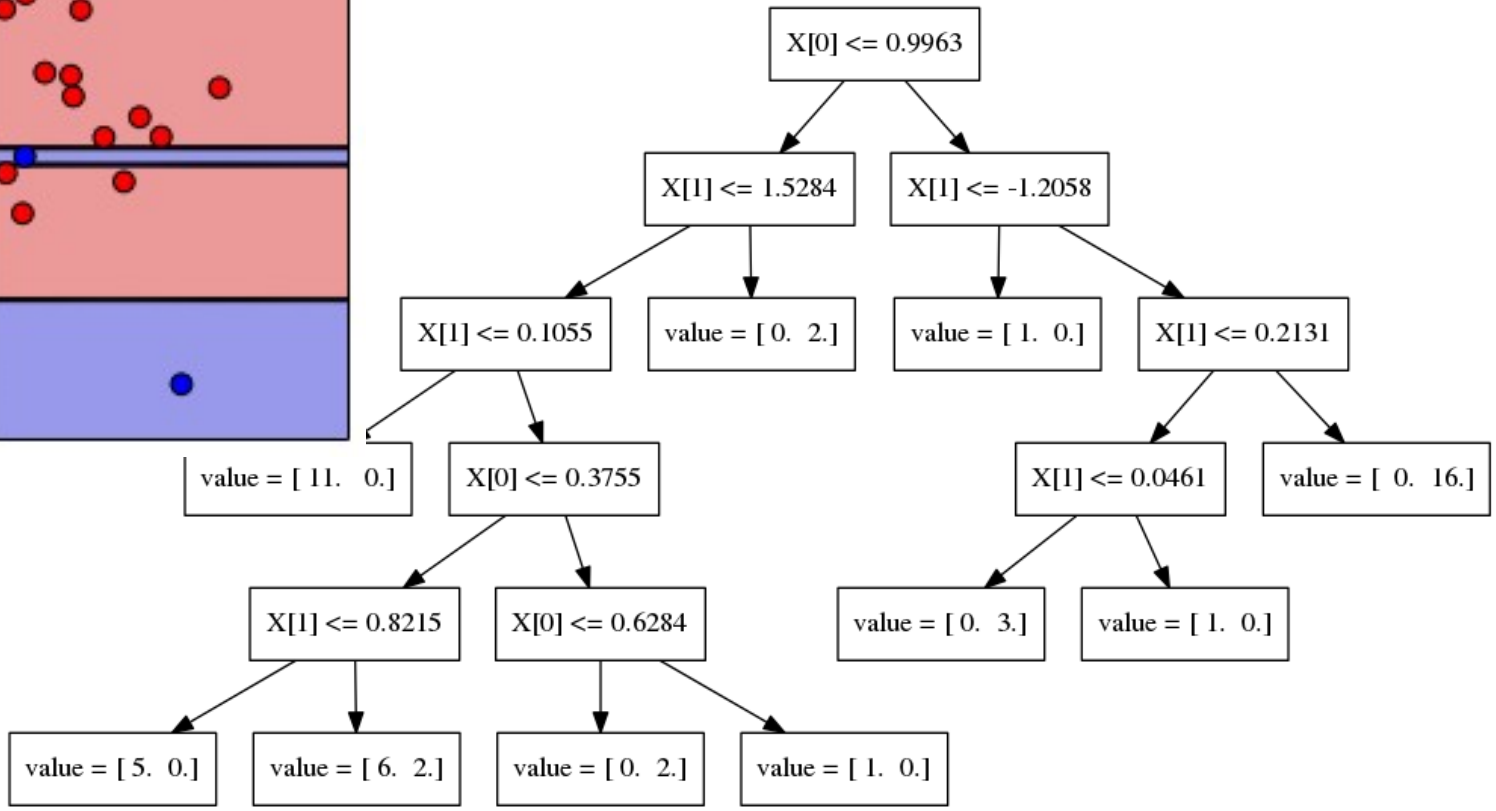
Decision Trees



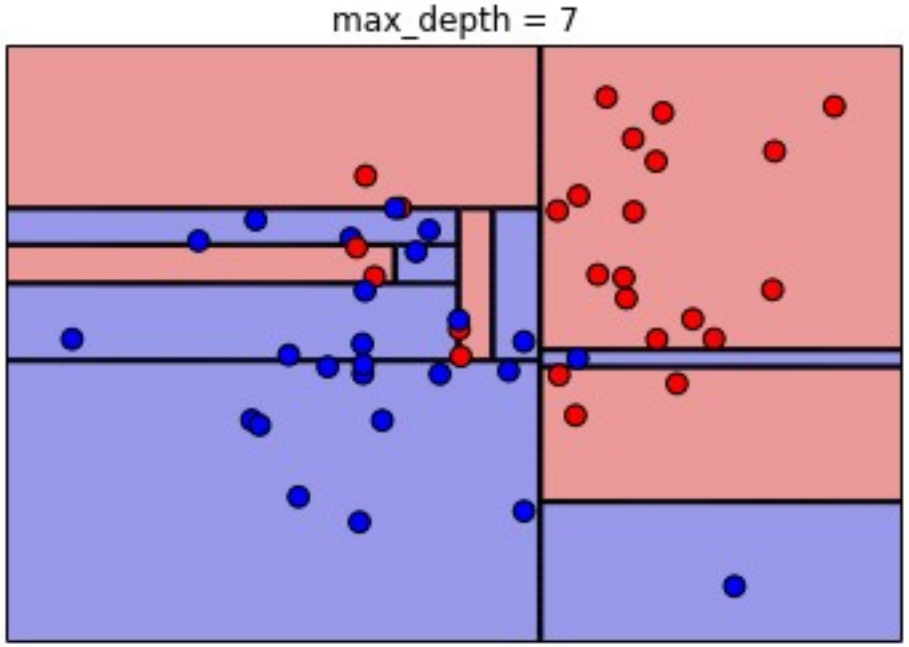


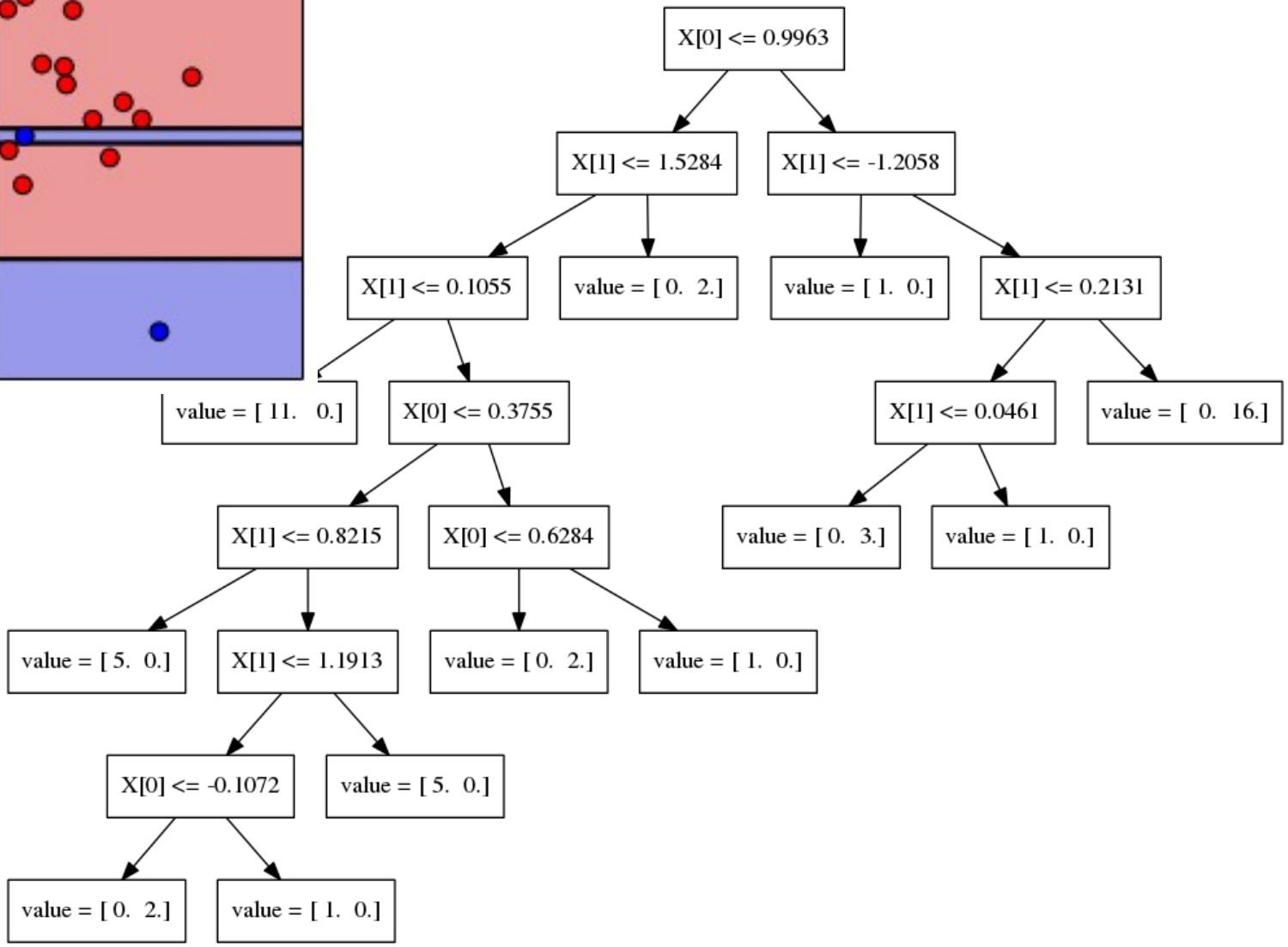
Decision Trees



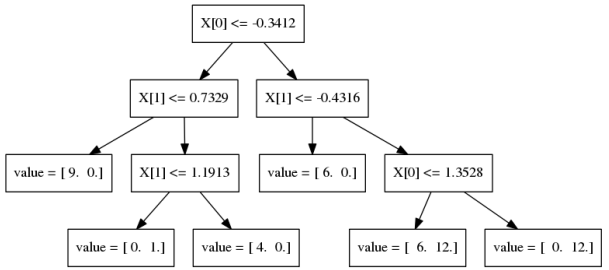


Decision Trees

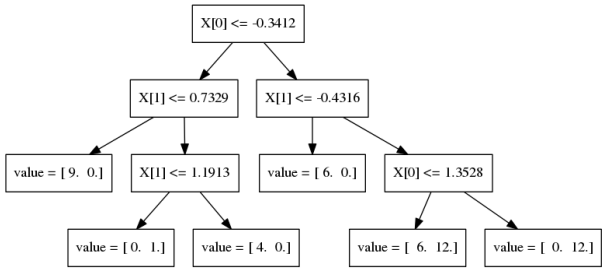


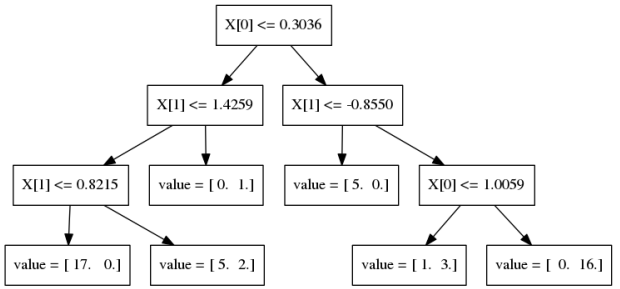


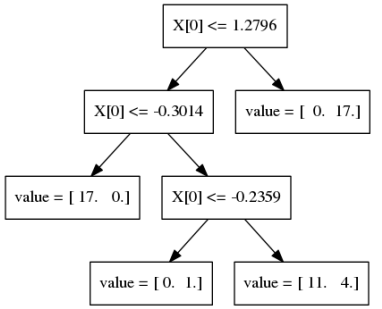
Random Forests



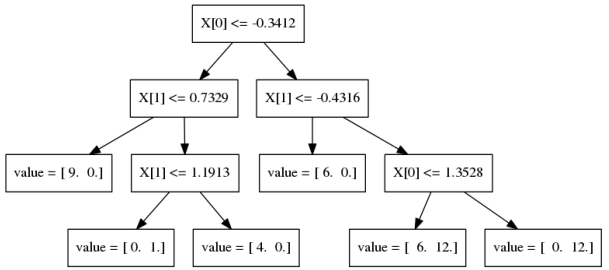
Random Forests

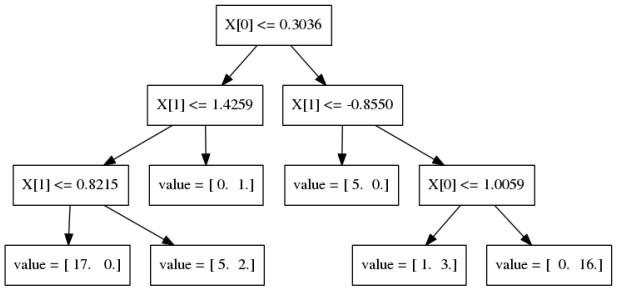


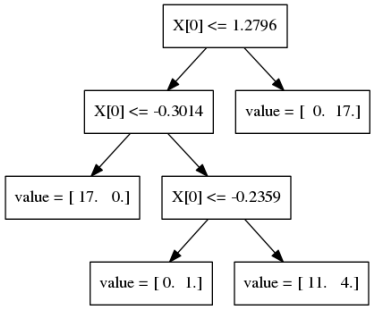


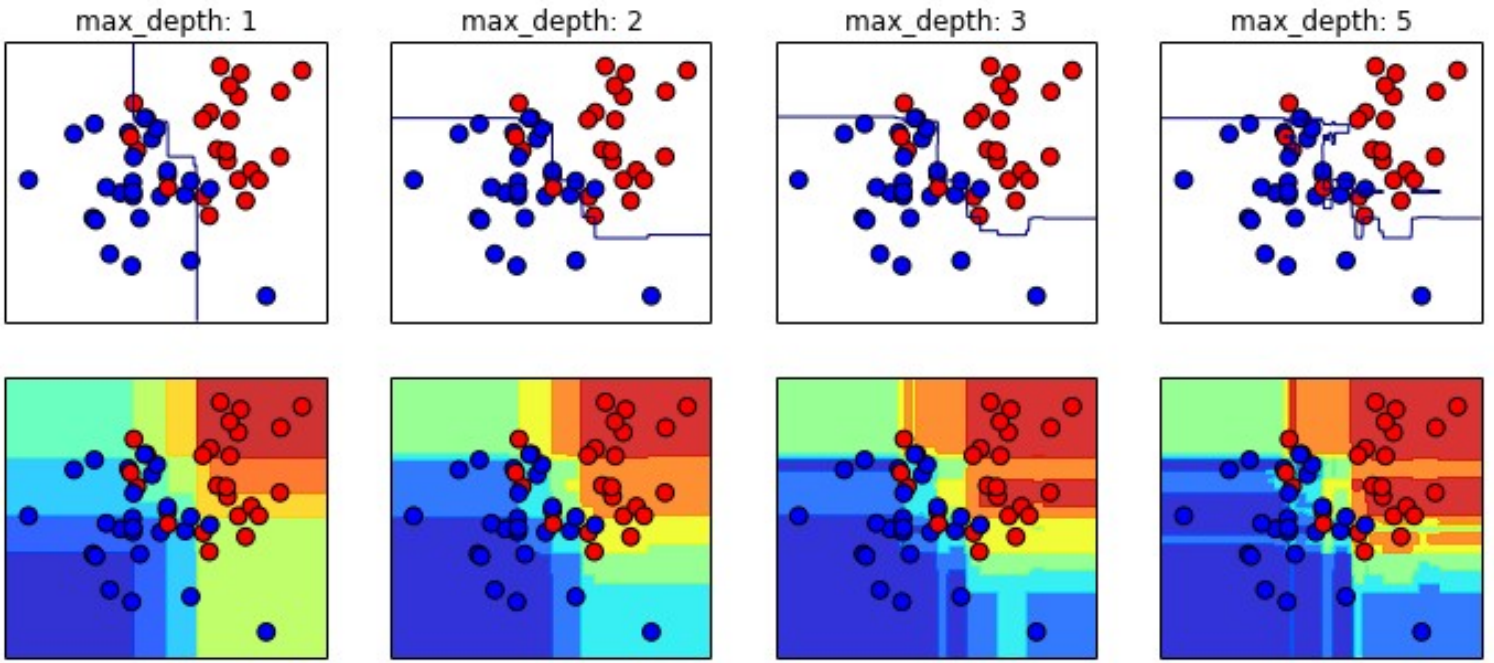


Random Forests



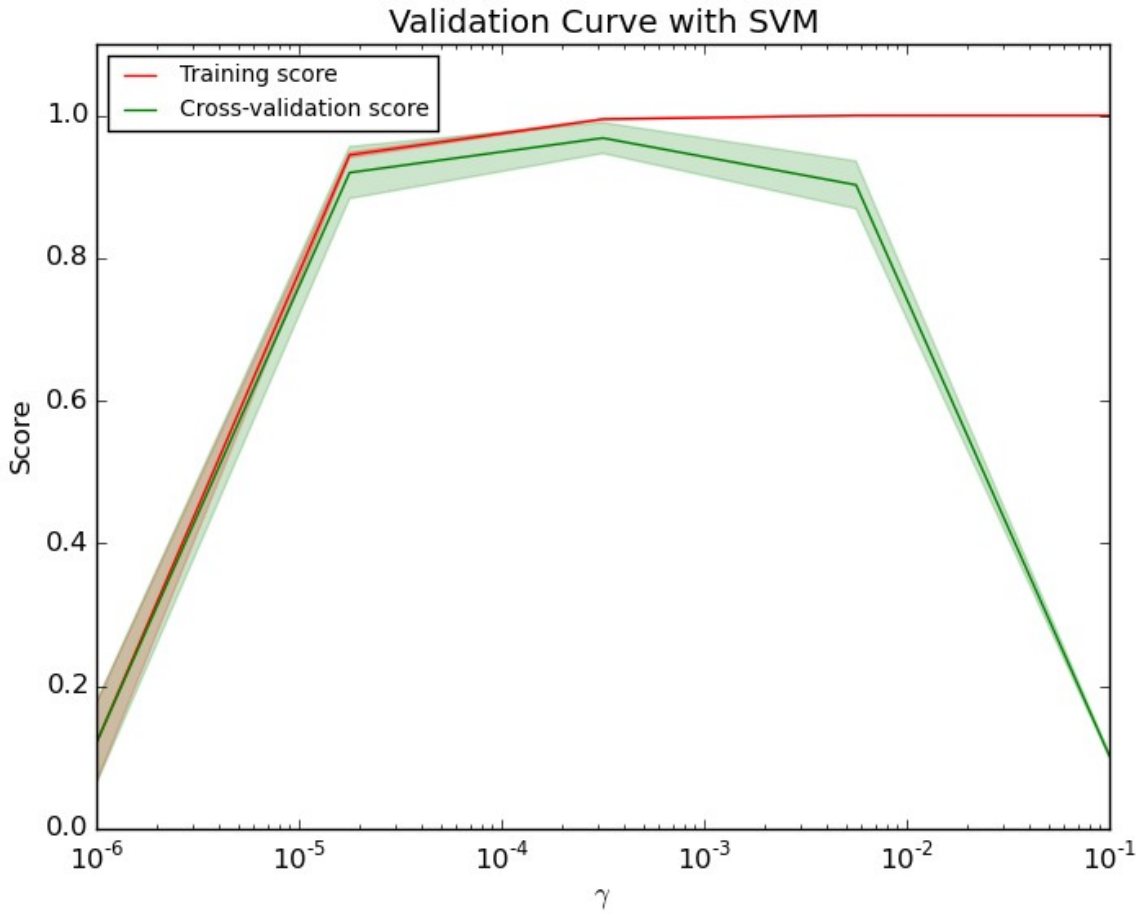






Validation Curves

```
train_scores, test_scores = validation_curve(SVC(), X, y,
    param_name="gamma", param_range=param_range)
```



Scaling Up

Three regimes of data

- Fits in RAM
- Fits on a Hard Drive
- Doesn't fit on a single PC

Three regimes of data

- Fits in RAM (up to 256 GB?)
- Fits on a Hard Drive (up to 6TB?)
- Doesn't fit on a single PC

Nobody ever got fired for using Hadoop on a cluster

Antony Rowstron, Dushyanth Narayanan, Austin Donnelly, Greg O'Shea, and Andrew Douglas

10 April 2012

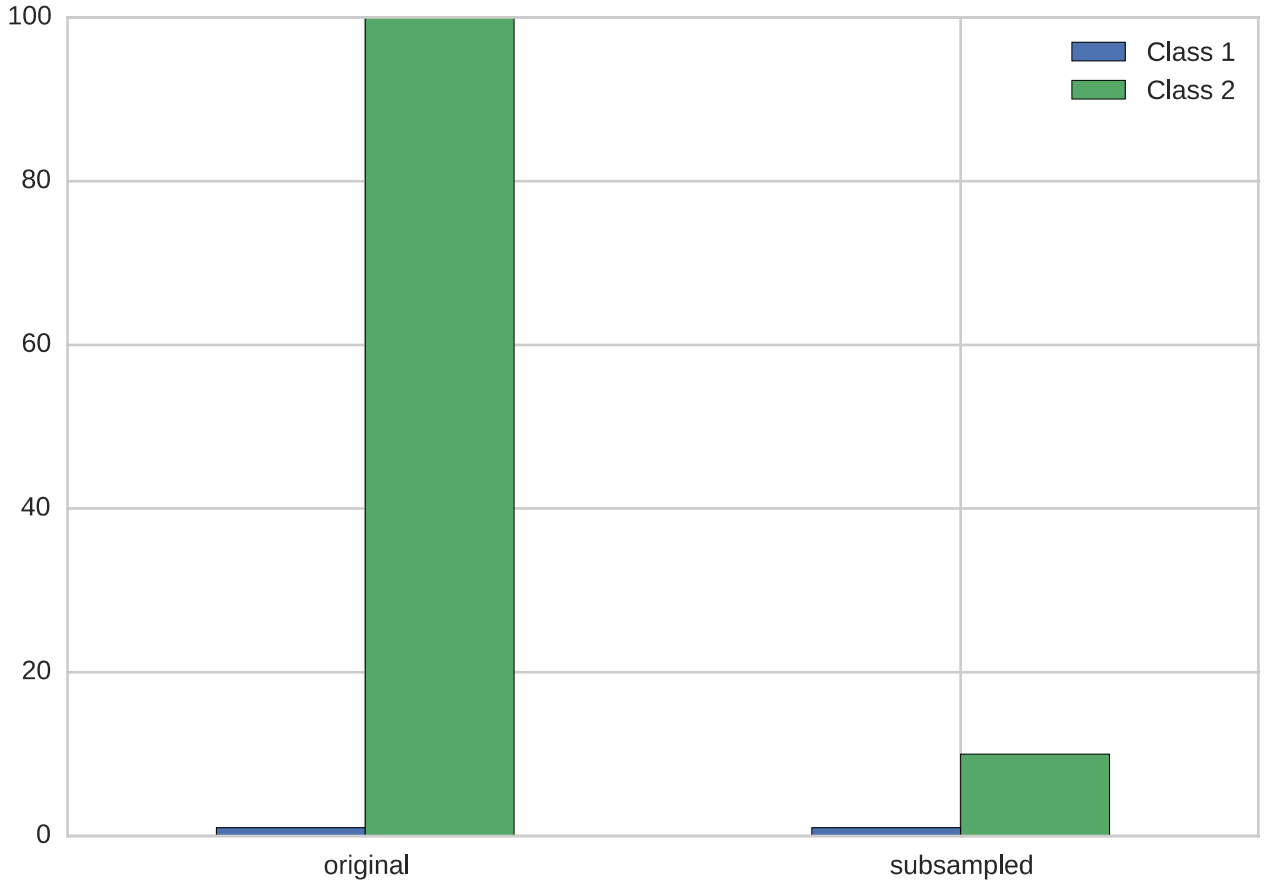
	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
Memory Optimized - Current Generation					
r3.large	2	6.5	15	1 x 32 SSD	$0.195 per Hour
r3.xlarge	4	13	30.5	1 x 80 SSD	$0.39 per Hour
r3.2xlarge	8	26	61	1 x 160 SSD	$0.78 per Hour
r3.4xlarge	16	52	122	1 x 320 SSD	$1.56 per Hour
r3.8xlarge	32	104	244	2 x 320 SSD	$3.12 per Hour
Storage Optimized - Current Generation					
i2.xlarge	4	14	30.5	1 x 800 SSD	$0.938 per Hour
i2.2xlarge	8	27	61	2 x 800 SSD	$1.876 per Hour
i2.4xlarge	16	53	122	4 x 800 SSD	$3.751 per Hour
i2.8xlarge	32	104	244	8 x 800 SSD	$7.502 per Hour

"256Gb ought to be enough for anybody."
- me

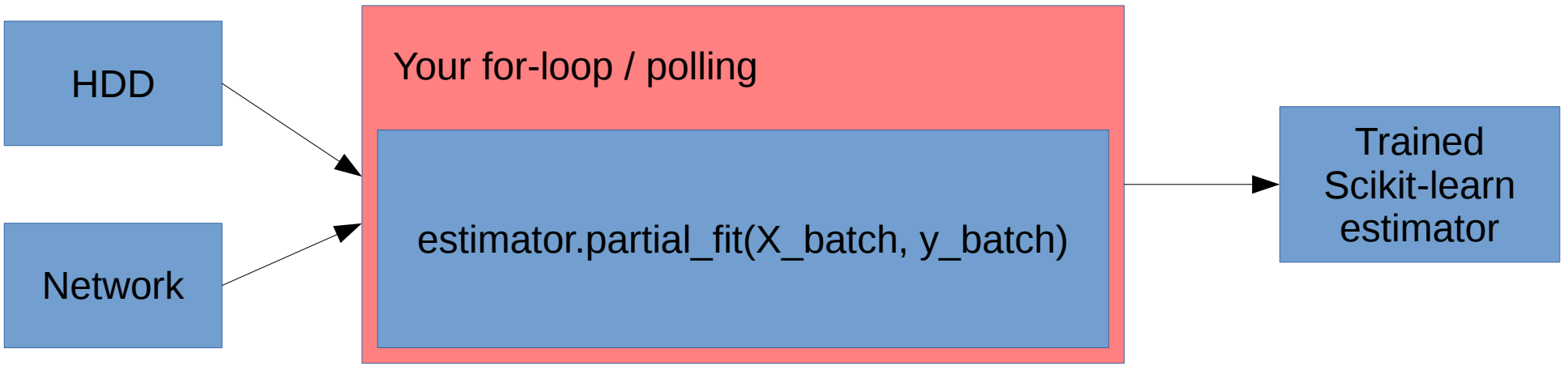
"256Gb ought to be enough for anybody."
- me

(for machine learning)

Subsample!



The scikit-learn way


HDD
Network
Your for-loop / polling
estimator.partial_fit(X_batch, y_batch)
Trained
Scikit-learn
estimator

Supported Algorithms

- All `SGDClassifier` derivatives
- Naive Bayes
- `MinibatchKMeans`
- `Birch`
- `IncrementalPCA`
- `MiniBatchDictionaryLearning`

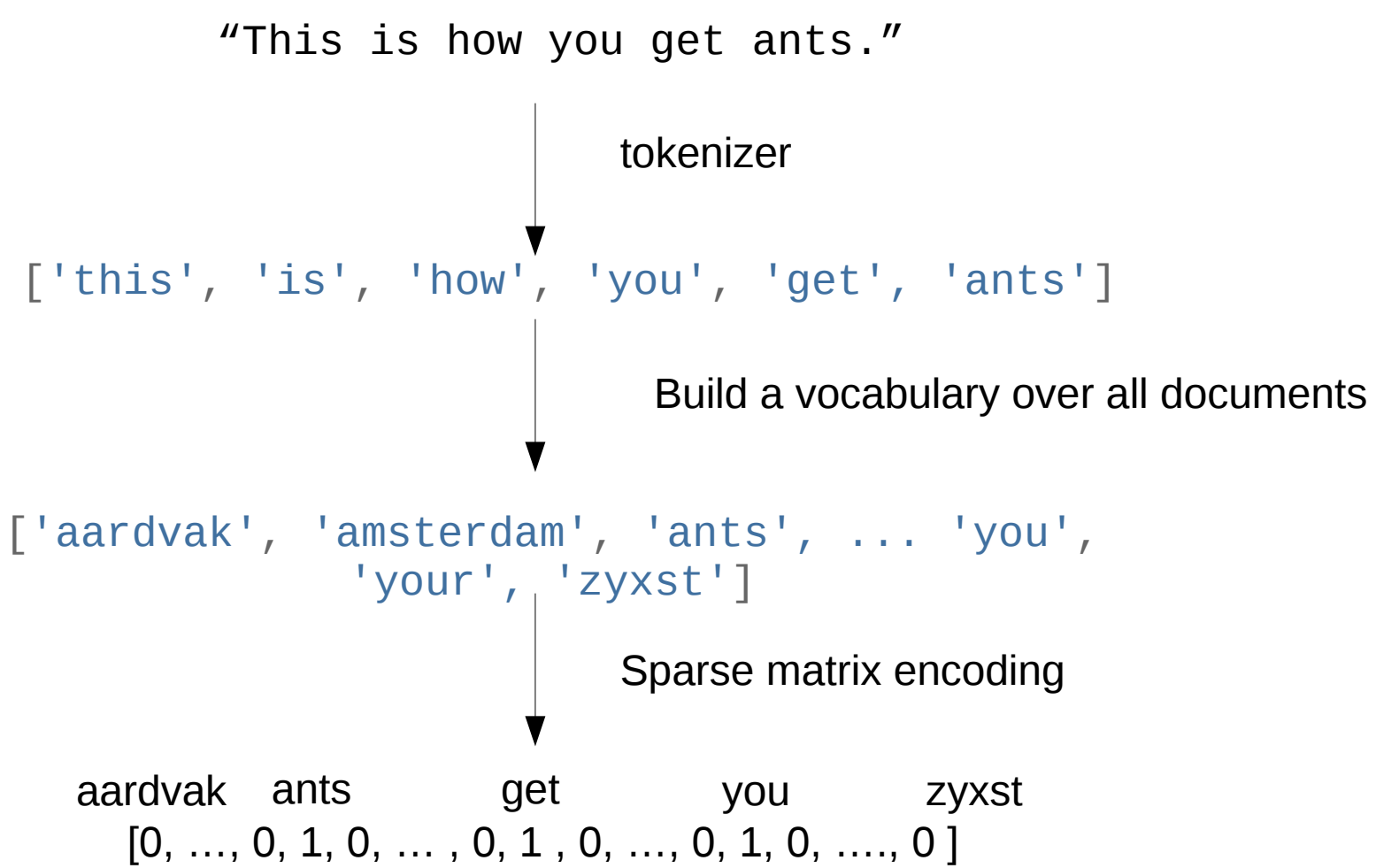
IPython Notebook:
Part 8 – Out Of Core Learning

Stateless Transformers

- `Normalizer`
- `HashingVectorizer`
- `RBFSampler` (and other kernel approx)

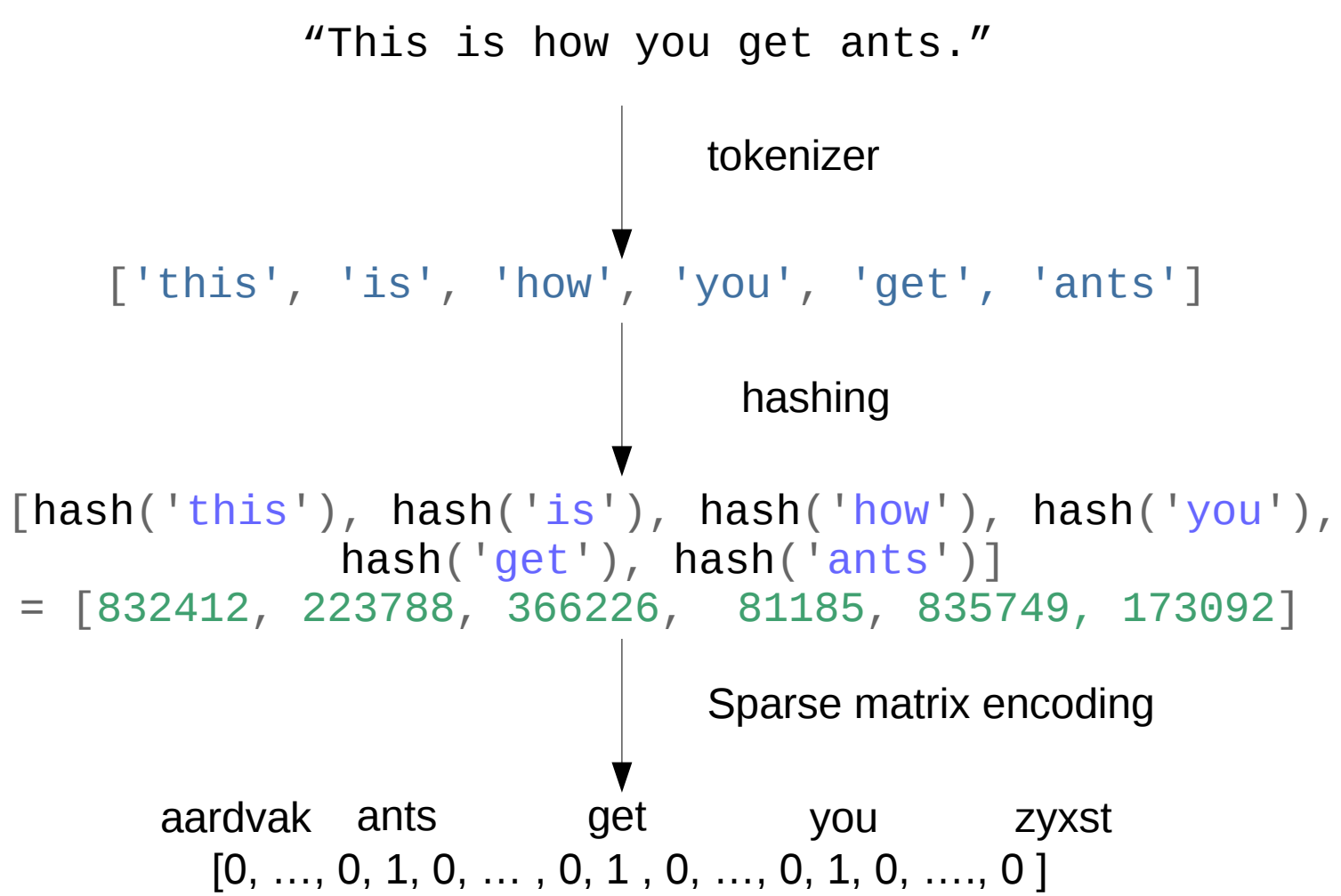
Bag Of Word Representations

`CountVectorizer / TfidfVectorizer`



Hashing Trick

`HashingVectorizer`



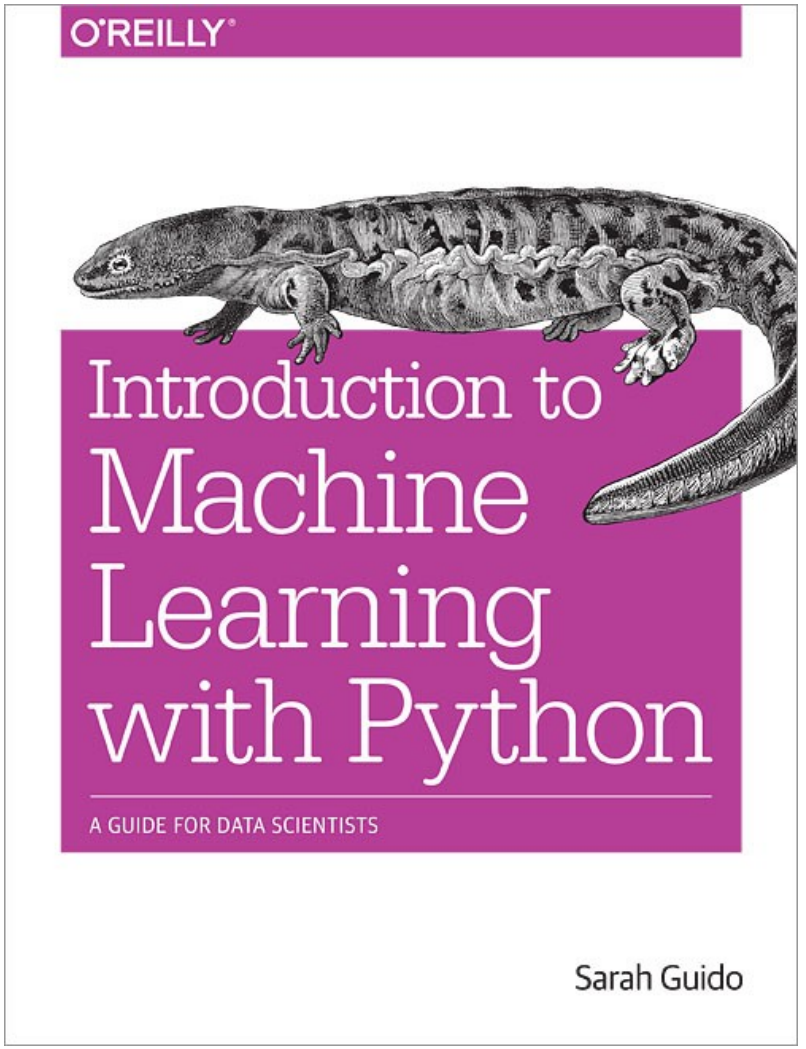
IPython Notebook:
Part 9 – Out Of Core Learning for Text

Video Series
Advanced Machine Learning with scikit-learn

50% Off Coupon Code: AUTHD

Video Series
Advanced Machine Learning with scikit-learn

50% Off Coupon Code: AUTHD



Thank you for your attention.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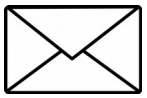
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